

## DEPARTMENT OF HEALTH AND ENVIRONMENTAL SCIENCES

**ADMINISTRATIVE RECORD  
SF FILE NUMBER**

0021539



TED SCHWINDEN, GOVERNOR

**1030100**

COGSWELL BUILDING

**STATE OF MONTANA**

HELENA, MONTANA 59620

September 27, 1982

**1244058 - R8 SDMS**

Dr. Henry Falk  
Centers for Disease Control  
Chief of Special Studies Branch  
Chronic Diseases Division CEH  
1600 Clifton Road, NE  
Atlanta, GA 30333

Dear Dr. Falk:

The Montana State Department of Health and Environmental Sciences has compiled information which suggests that emissions from the East Helena, Montana industrial sources (ASARCO) and American Chemet may adversely affect the health of the population. ASARCO has a primary lead smelter while American Chemet processes lead bearing zinc material. The enclosed information includes: 1) an older study "Helena Valley, Montana, Area Environmental Pollution Study" which was performed by EPA in 1969 and 1970, and 2) recent information which gives metal depositions; identifies sources of particulates and lead; lists garden, soil, road and house dust metal concentrations; describes recent powerful chemical-mass-balance data analysis techniques; lists traffic counts; shows population information; and presents 1975 East Helena children blood-lead data. If you have questions about this data, please contact Mr. David Maughan, who either collected or supervised the collection of the recent data excepting the blood lead information. He can be reached at (406) 449-3454 or FTS 587-3454.

Montana requests CDC's assistance in performing a study which might:

1. Analyze blood-lead and erythrocyte protoporphyrin levels over a one-year period of time;
2. Study the highest risk population including infants;
3. Identify sources of household, garden vegetable, soil, etc. lead which cause elevated levels in the population;
4. Include adverse health effects caused by high concentrations of arsenic, cadmium, copper and possibly several other metals; and
5. Utilize technical and laboratory facilities of CDC.

We realize the above may be lofty study goals, but also that you may be able to make suggestions for such a study based on your extensive background.

Dr. Henry Falk  
Page 2  
September 27, 1982

This is perhaps the best characterized study area known. We feel we understand metal make-up within the area and hope to utilize this large source data base in identifying particulates which adversely affect the human population. We, therefore, recommend an extensive study if possible.

At present we have some technical and laboratory facilities available for the proposed study. Mr. Daniel Graybill, a public health intern, will be available until the end of 1982, to assist us with the project. We understand you may be able to come to Montana with others to discuss and plan the study, possibly in October.

Please study this request and contact me at (406) 449-4740 if you have any questions.

Sincerely,

*John S. Anderson*  
John S. Anderson, M.D.  
Administrator  
Health Services Division

JSA:dag  
Enclosures

## East Helena Area Metal Deposition from Primary Lead Smelter

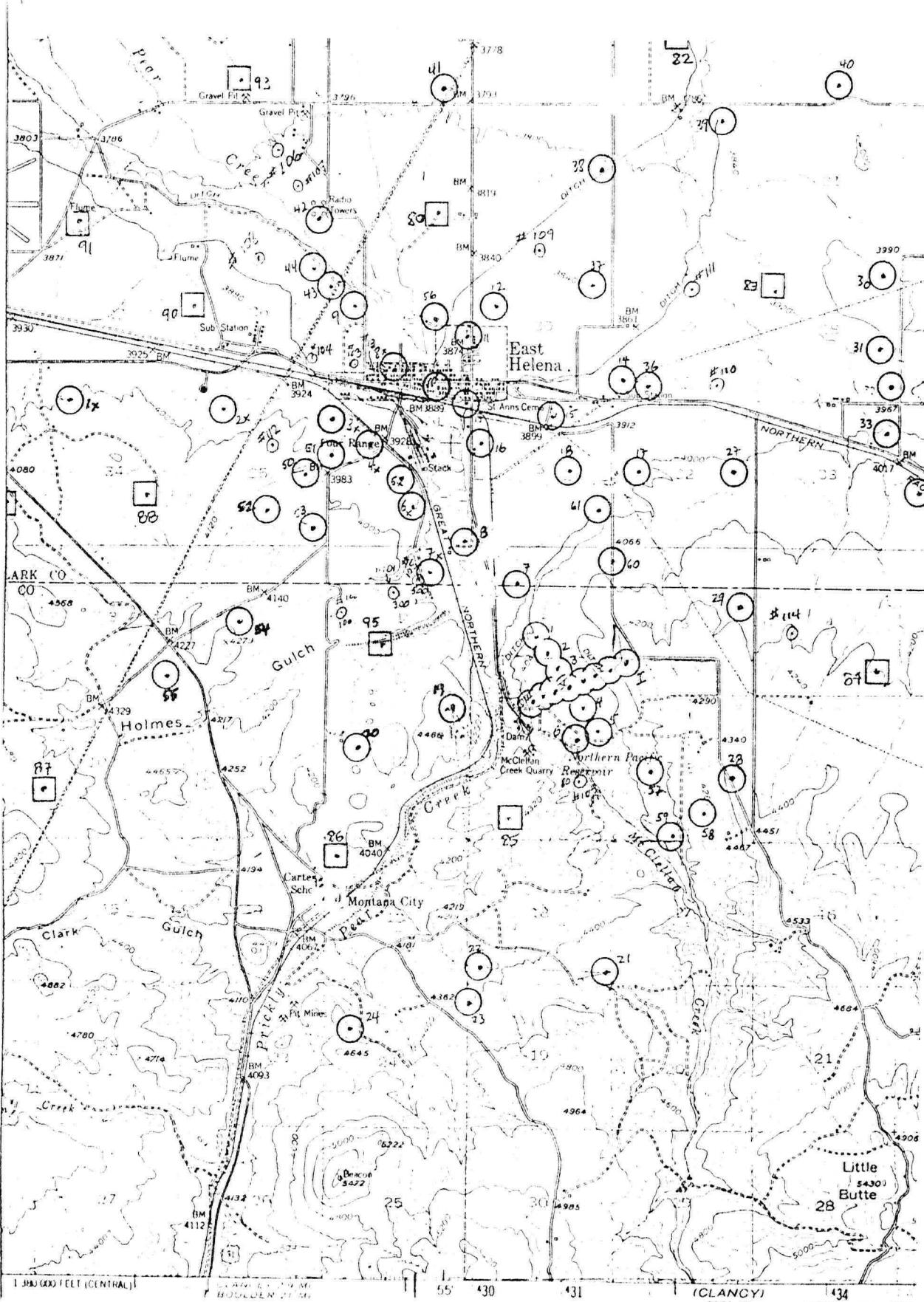
In 1978 East Helena area ranchers experienced cattle losses caused by high concentrations of lead. During the period other metals were not measured in the animal tissues or blood. These losses triggered a study to measure metal deposition onto agricultural land around the smelter.

The study was designed to measure annual deposition of lead, cadmium, arsenic and zinc concentrations, and included an eight by ten mile area with the East Helena smelter approximately centered within the area. Since cattle deaths occurred during winter periods, data collection was accomplished to emphasize the winter season.

Snow cores (Figure 1) were collected in 1979 at locations surrounding the smelter. These cores were analyzed by atomic absorption analyses for the elements: lead, cadmium, zinc and arsenic. Concentrations were computer contoured to show concentration ranges. These data are shown for the four elements in Figures 2, 3, 4 and 5. Sampling points are marked by a plus (+) symbol. The contours were overlaid on USGS topographical maps to show relative distances and locations.

Snow was of sufficient depth during the cold winter of 1978-79 to satisfy sampling requirements. As long as snow remains frozen, it does not allow particulates to migrate downward. Consequently particles which settle on the snow remain until thawing occurs. During this study, snow remained on the ground for a full 91 days without thawing, though some evaporation may have occurred. Generally, the use of snow as a particulate collecting medium will present conservative data rather than overestimating metal concentration.

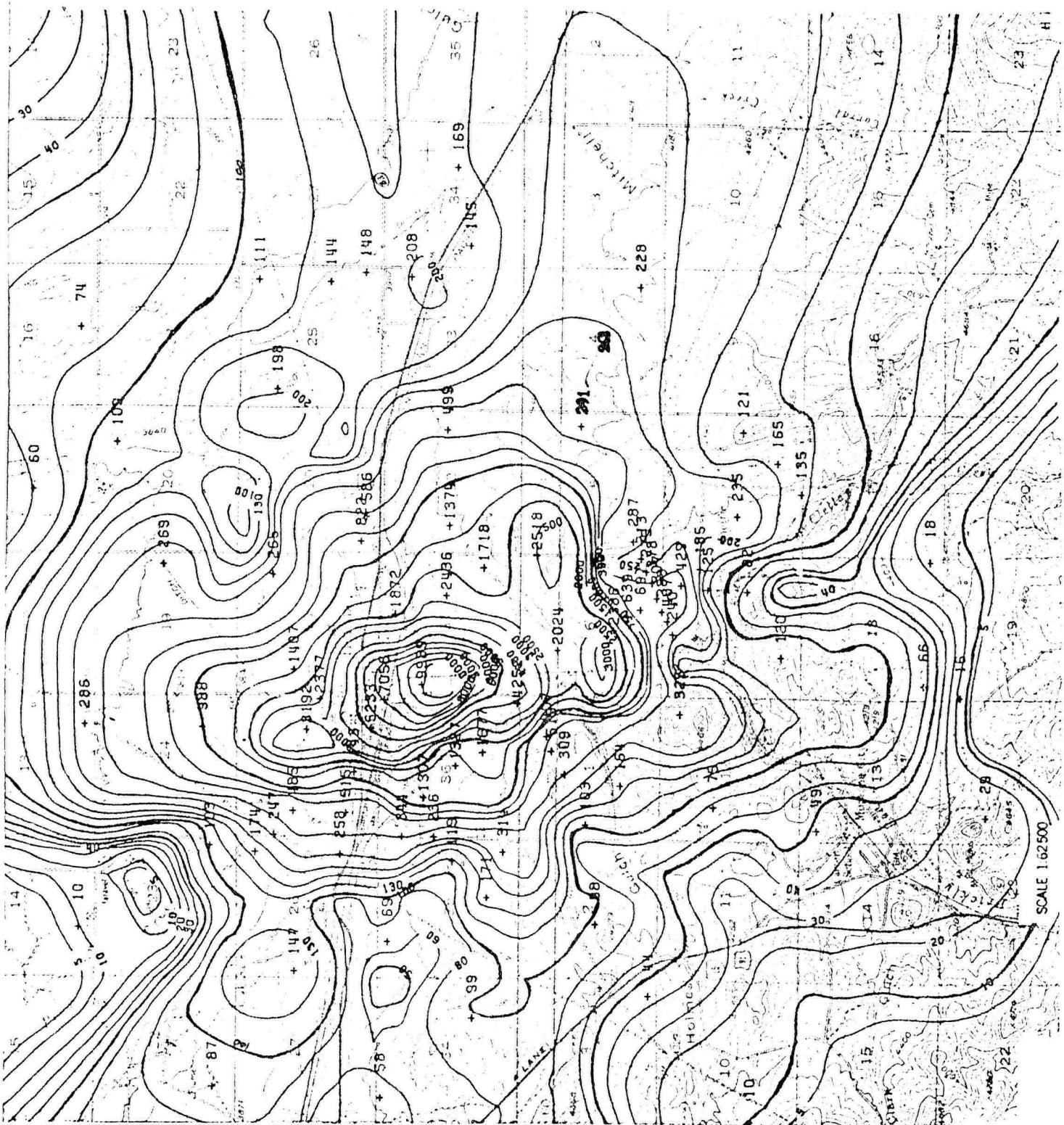
0021542



East Helena snow core sampling locations. 1 inch = 1 mile.

Figure 1

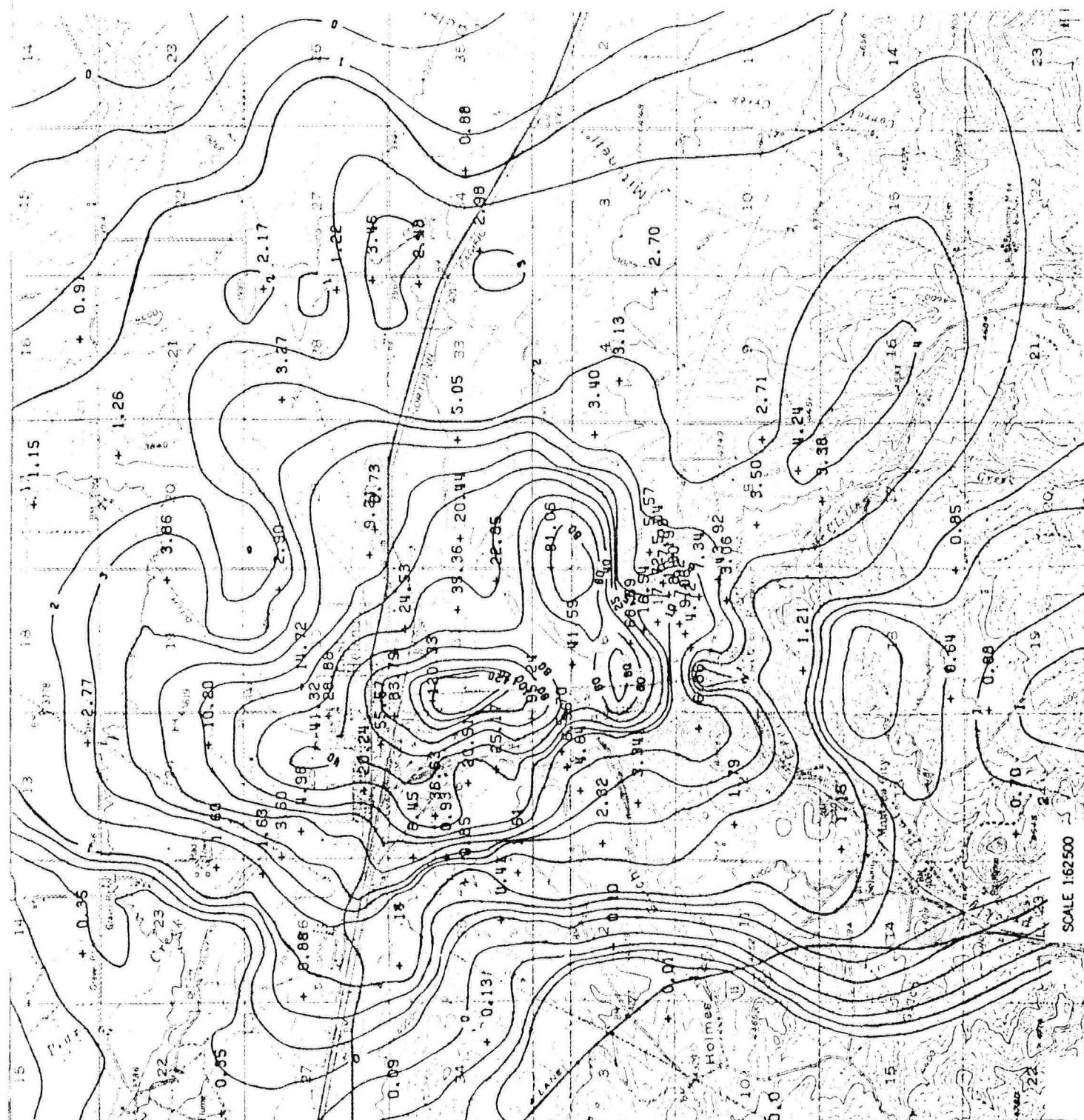
0021543



TWO-DIMENSIONAL PLOT OF LEAD CONCENTRATIONS FOR EAST HELENA, MONTANA.  
 Isopleth contours show greater than 10,000 micrograms of lead per snow core just East of the ASARCO primary lead smelter to less than 5 near the perimeters of the plot. Contours are overlaid on a USGS topographical map where 1 inch equals 1 mile.

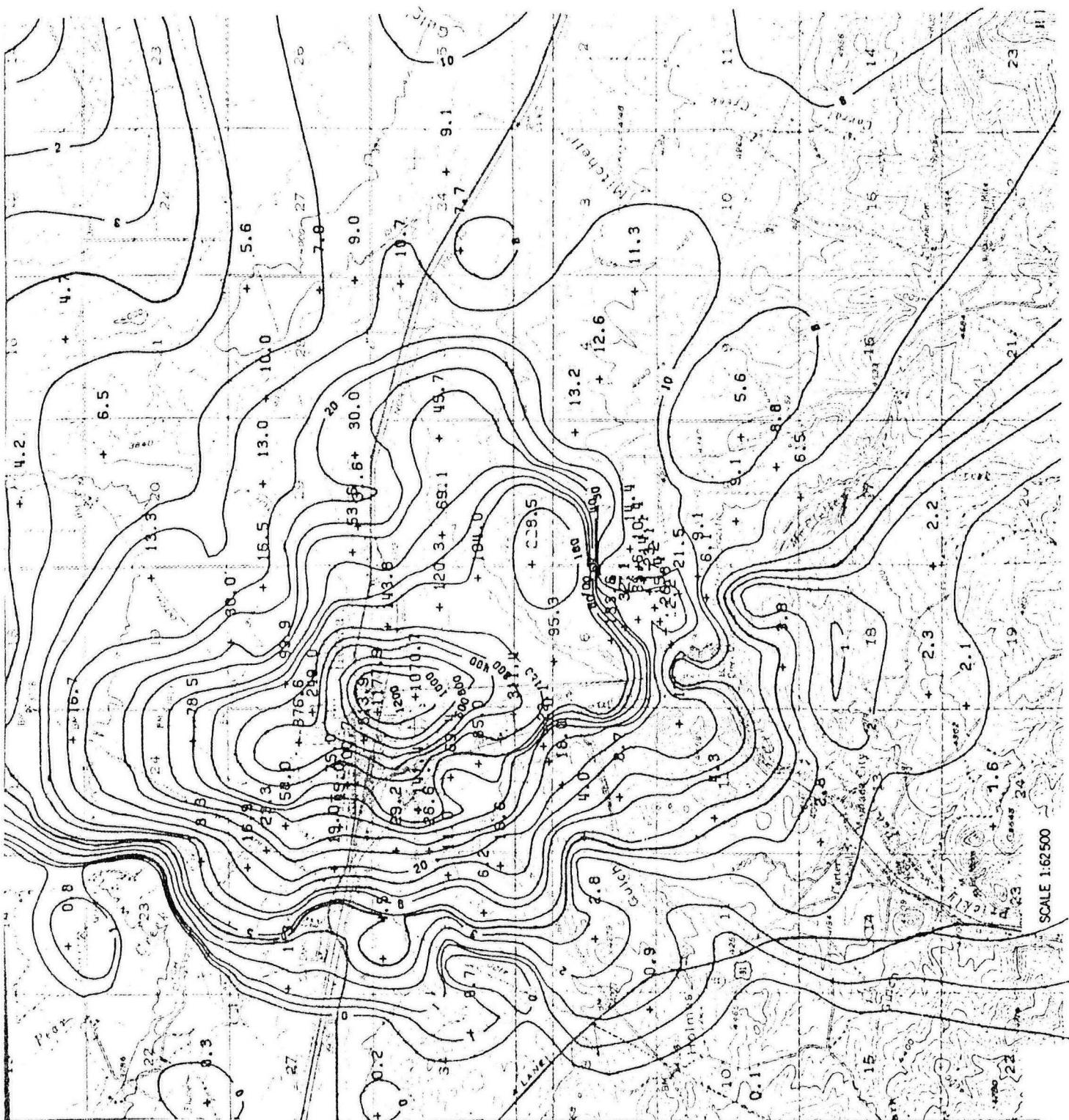
Figure 2

0021544

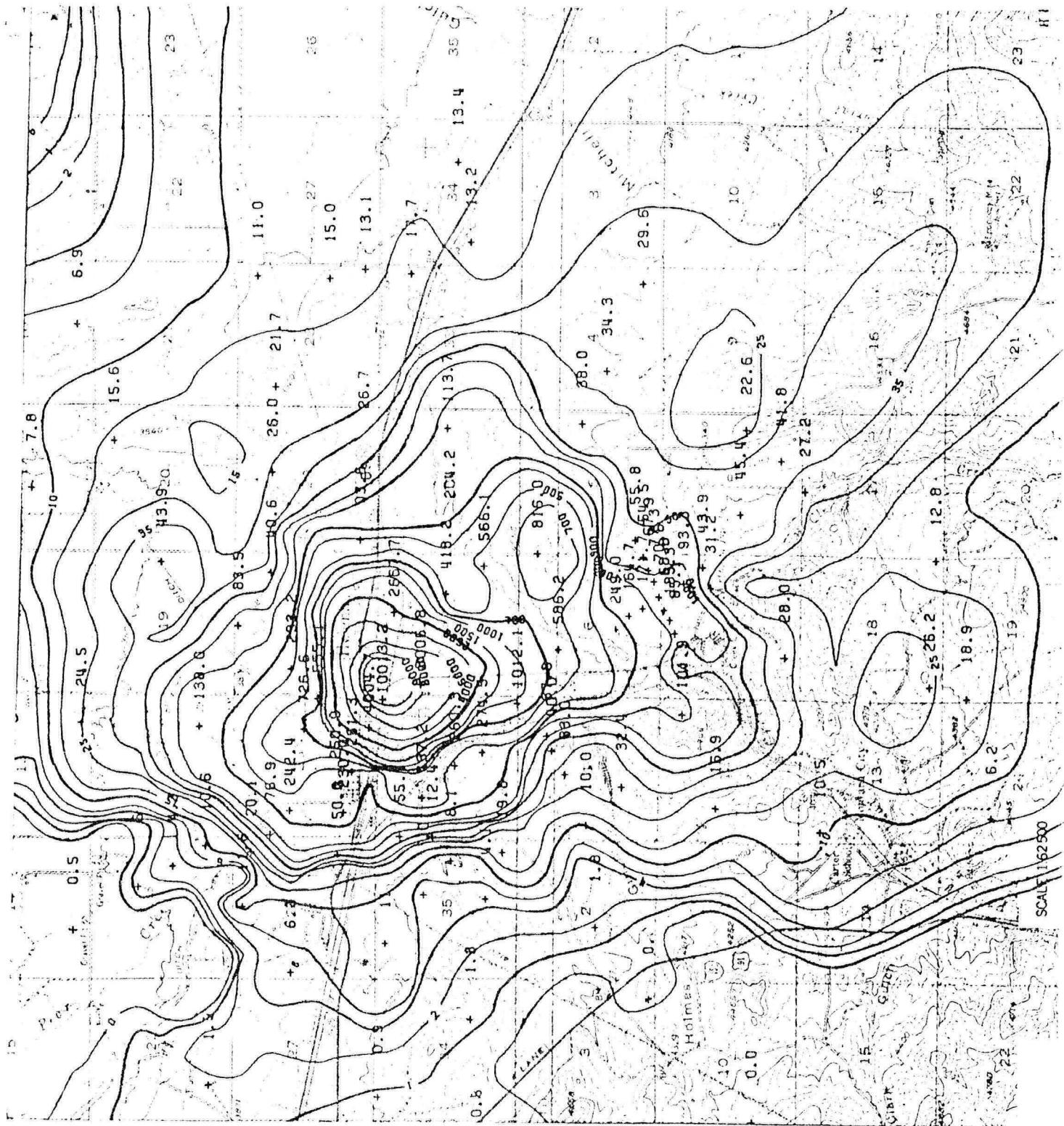


TWO-DIMENSIONAL PLOT OF CADMIUM CONCENTRATIONS FOR EAST HELENA, MONTANA. Isopleth contours show greater than 120 micrograms of cadmium per snow core just East of the ASARCO primary lead smelter to less than 0.01 near the perimeter of the plot. Contours are overlaid on a USGS topographical map where 1 inch equals 1 mile.

Figure 3



0021546



TWO-DIMENSIONAL PLOT OF ZINC CONTRATIONS FOR EAST HELENA, MONTANA.  
Isopleth contours show greater than 10,000 micrograms of zinc per snow  
core just East of the ASARCO primary lead smelter to less than 0.1 near  
the perimeter of the plot. Contours are overlaid on a USGS topographical  
map where 1 inch equals 1 mile.

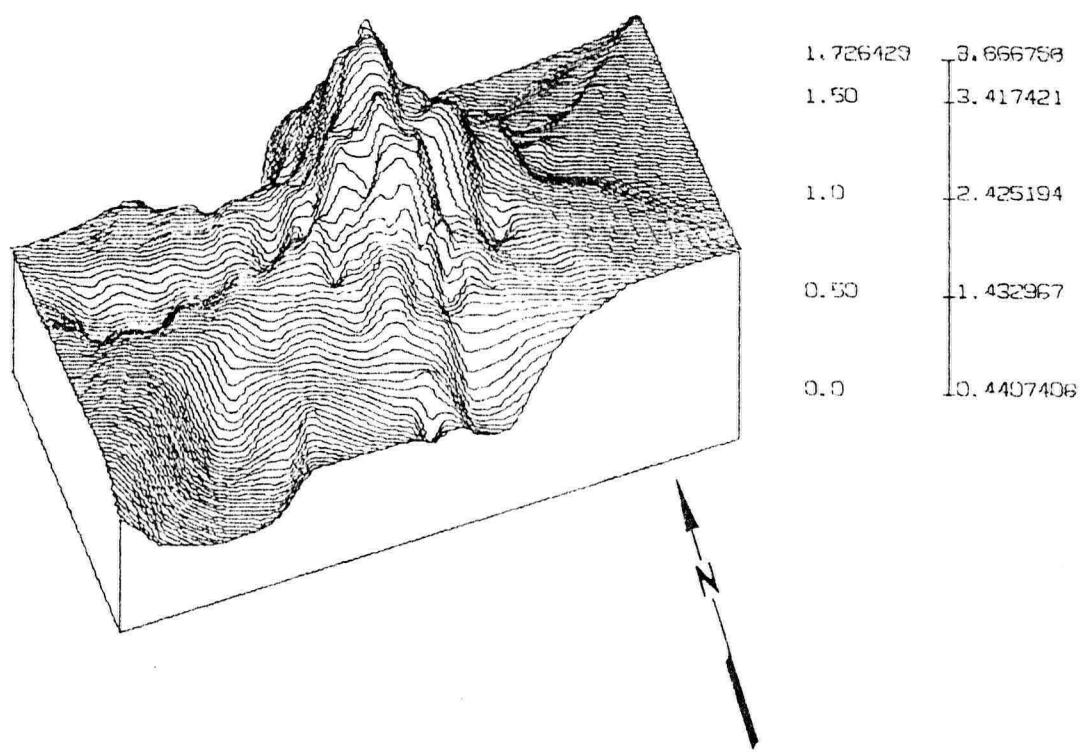
Figure 5

During the ninety-one days of particulate collection, wind conditions approximated annual wind conditions. It was assumed, therefore, that the three months of particulate collection was sufficient to extrapolate the data to annual deposition values. With contoured levels and concentrations values shown in Figures 2 through 5, metal deposition rates were calculated. Furthermore, metal deposition could be calculated with a planimeter for subareas within the study area.

The same snow core data base was computer analyzed in a three-dimensional manner such that volume integrations, rather than area integrations, represented metal depositions. This provided a second method for calculating metal deposition, and made fallout measurement onto any subarea possible where boundaries could be delineated using longitude-latitude or other similar measurement systems. Figure 6 shows a three dimensional plot of lead deposition for the 10 by 8.4 mile study area. One views the geographical area here from the SSW. The peak is about one-half mile east of the main stack. The scale is linear in North-South, East-West directions and logarithmic in the vertical metal concentration dimension. While the baseline of the three-dimensional plot represents zero concentration, it is clearly seen for lead that significant concentrations still exist at the edges of the figure.

It is possible with these three-dimensional analyses to plot only those metal depositions of interest. For example, Figures 7, 8 and 9 show some of the subareas seen in Figure 10.

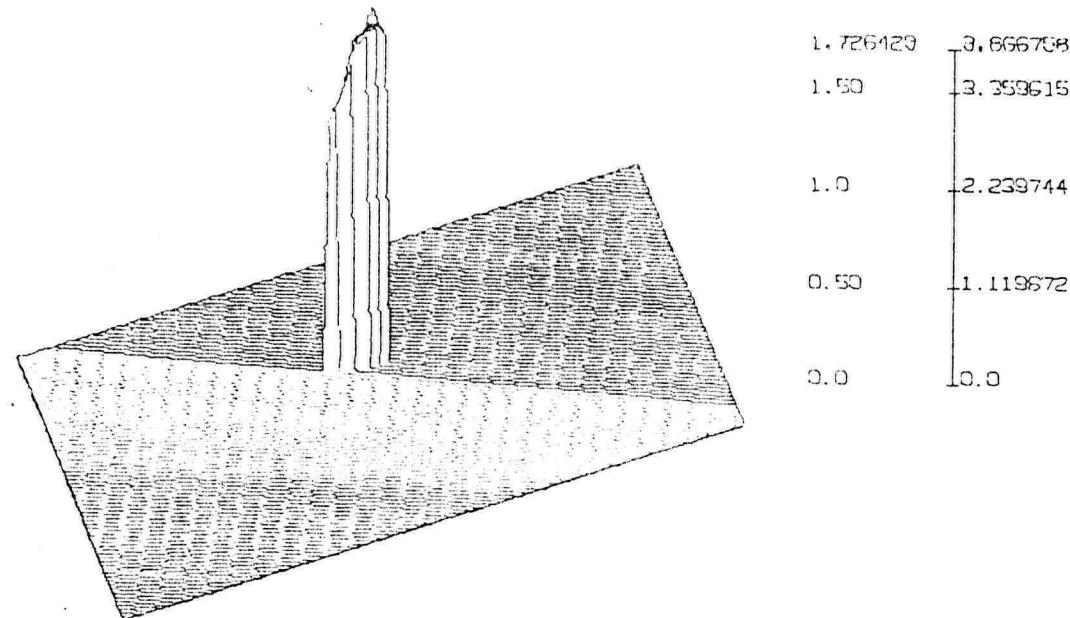
Results of this work are summarized in Table 1. Nearly 15 tons of lead per year fall onto populated lands. Twenty-nine tons of combined lead, cadmium, zinc and arsenic metals fall into these same populated lands. As can be seen from Figures 2 through 5, if a child ate the snow equivalent of one 12 oz. size can of pop, he would simultaneously ingest 5-10 milligrams of lead, 5-10 mg. of zinc, 0.05 to 0.10 mg cadmium, and 0.5 to 1.2 mg of arsenic.



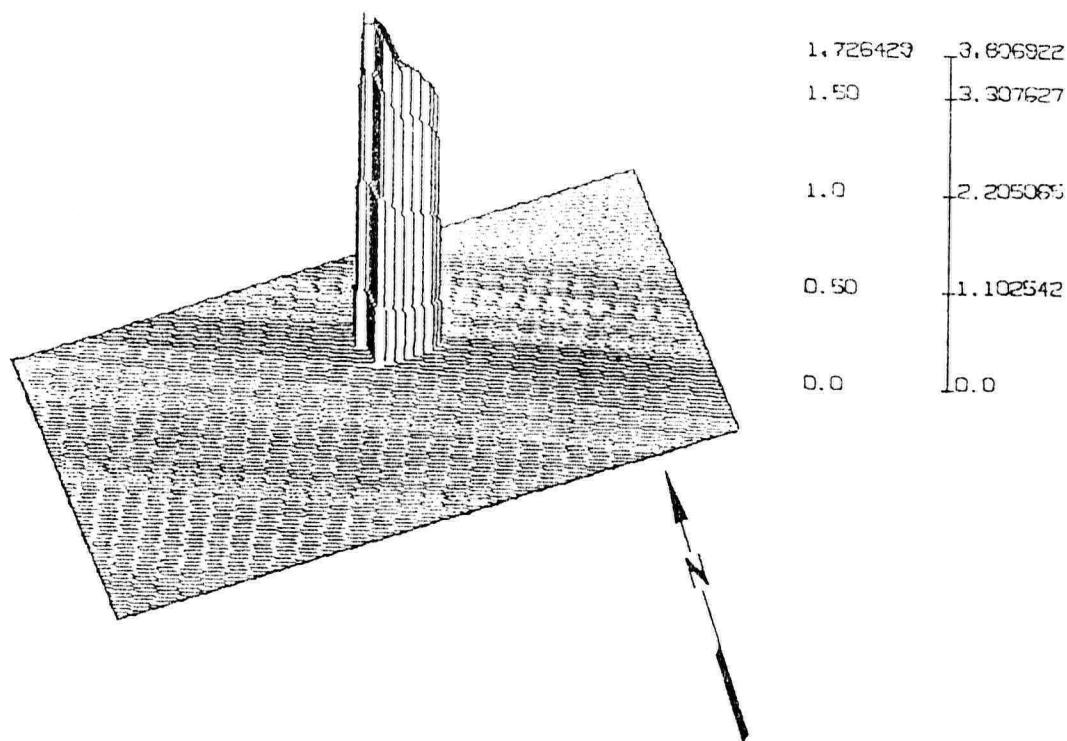
ALL OF STUDY AREA

THREE-DIMENSIONAL PLOT OF LEAD CONCENTRATIONS IN THE EAST HELENA AREA. Data obtained from snow core sampling in 1979. The base of the plot which runs East-West and North-South, is linear in scale and is expressed as miles. The vertical dimension is logarithmic; the units are micrograms per core of snow sampled. The plot is viewed from an elevated point 30° West of South. The base represents zero concentration.

Figure 6



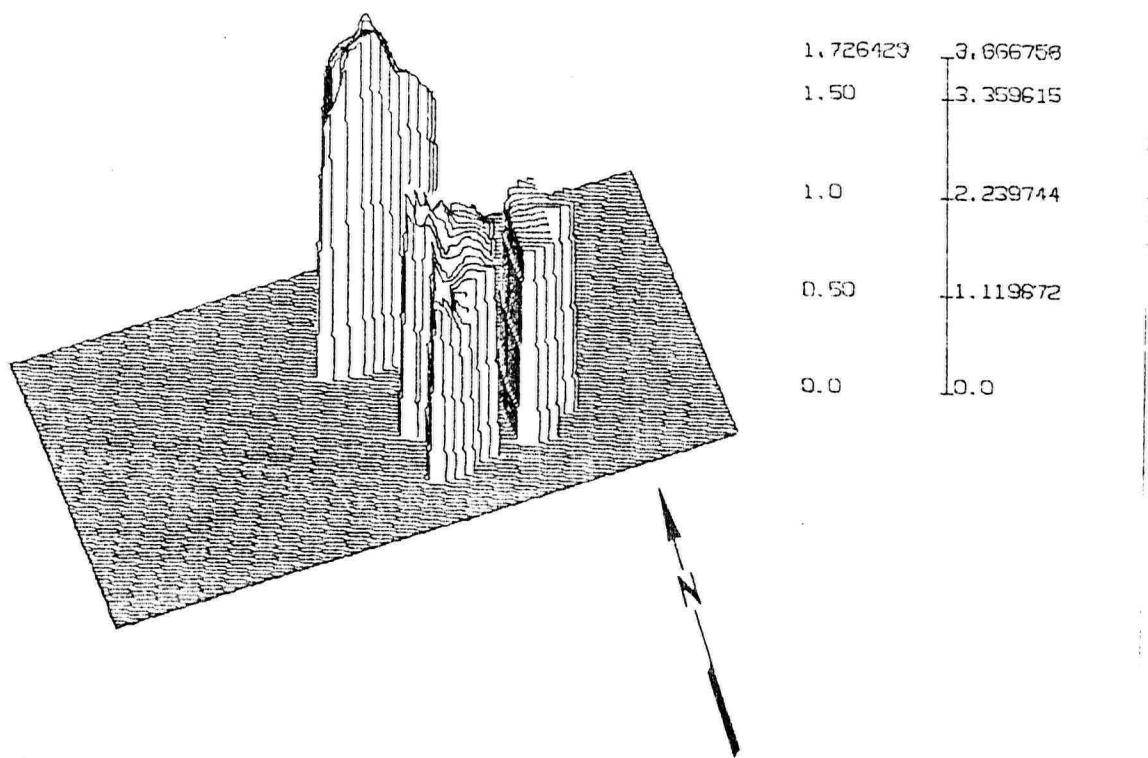
SUB AREA 2



SUB AREA 5

THREE-DIMENSIONAL PLOTS OF LEAD CONCENTRATIONS IN EAST HELENA, MONTANA (Sub area 2) and for the East Gate Subdivision (Sub area 5) which is just East of the city. Only sub areas 2 and 5 were plotted--other areas were suppressed by the computer. E-W and N-S dimensions are linear and in miles; the vertical is logarithmic in scale and expressed as micrograms of lead per snow core.

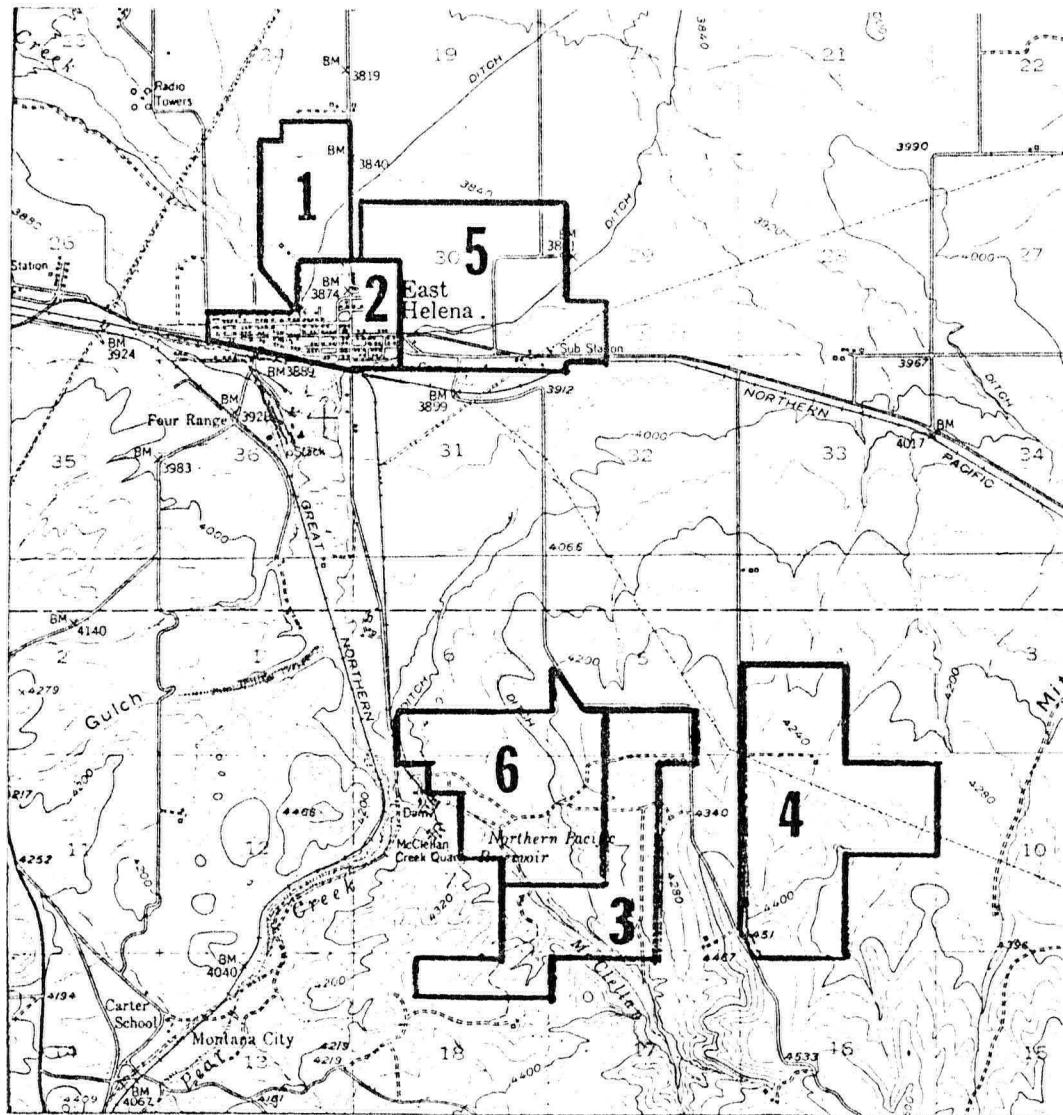
Figure 7



ALL 6 SUB AREAS

THREE-DIMENSIONAL PLOTS OF LEAD CONCENTRATIONS FOR EAST HELENA SUB AREAS. East-West and North-South dimensions are linear and in miles; the vertical component is logarithmic and in micrograms of lead per core of snow.

Figure 9



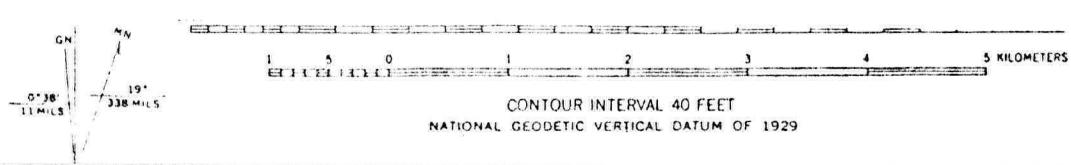
Example Areas Where Three-Dimensional Analyses Yielded Metal Deposition onto East Helena City and Agricultural Lands.

Figure 10

12

terior program  
River Basin

Stereoplanoigraph methods  
check 1950  
ian datum



Some wheat sampling has also been performed within the area. The closest wheat field lies south and adjacent to the smelter. Uncontaminated wheat kernels, i.e. those removed without being contaminated by dust from the outside coverings (spikules) of the wheat head itself, gave total lead concentrations of 4.5 ppm. These same kernels appear shrunken and shriveled in size and appearance. It appears that several thousand acres of wheat are contaminated by smelter emissions and experience varying percentages of yield loss up to about 45 percent. Increased protein percentages appear to correlate with the amount of stress experienced by the wheat plants.

Table 1

Annual Metal Deposition onto East Helena  
City, Subdivision and Agricultural Areas

<u>Areas</u>	Concentration (tons/year)			
	Lead	Cadmium	Zinc	Arsenic
Total-two dimensional analyses	80.060	1.205	30.976	6.076
Total-three dimensional analyses	85.227	1.207	32.489	6.237
Sub-areas				
three-dimensional analyses				
1. Rancher*	3.720	0.0454	1.2744	0.3866
2. City-East Helena	7.092	0.0849	6.8819	0.9086
3. Rancher	0.412	0.0083	0.0930	0.0192
4. Rancher	0.862	0.0140	0.1435	0.0427
5. Subdivision	7.154	0.0872	6.0242	0.6707
6. Rancher*	0.701	0.0159	0.1865	0.0375

\*Areas where significant cattle losses occurred

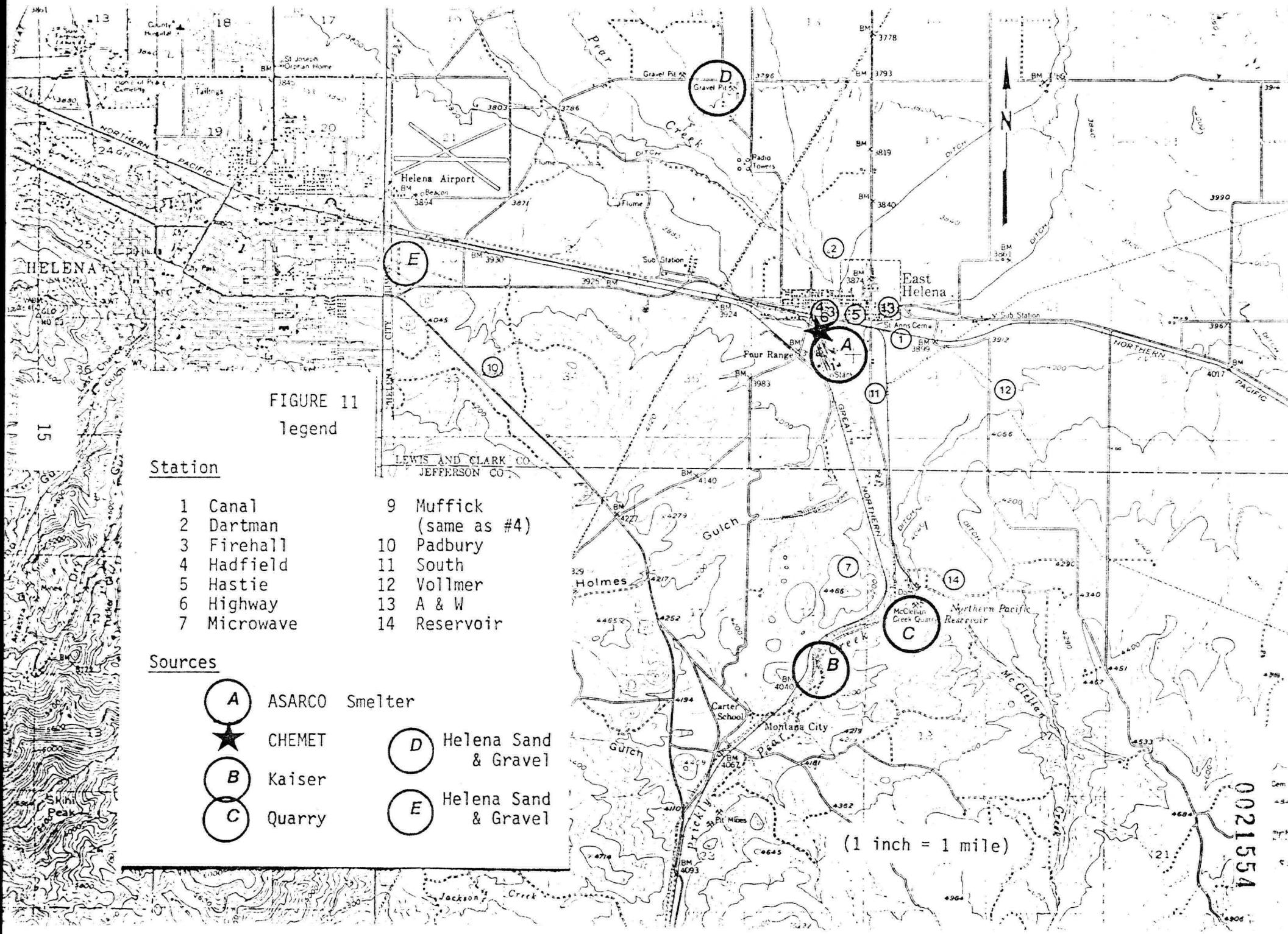
## Particulate Source Identification Studies

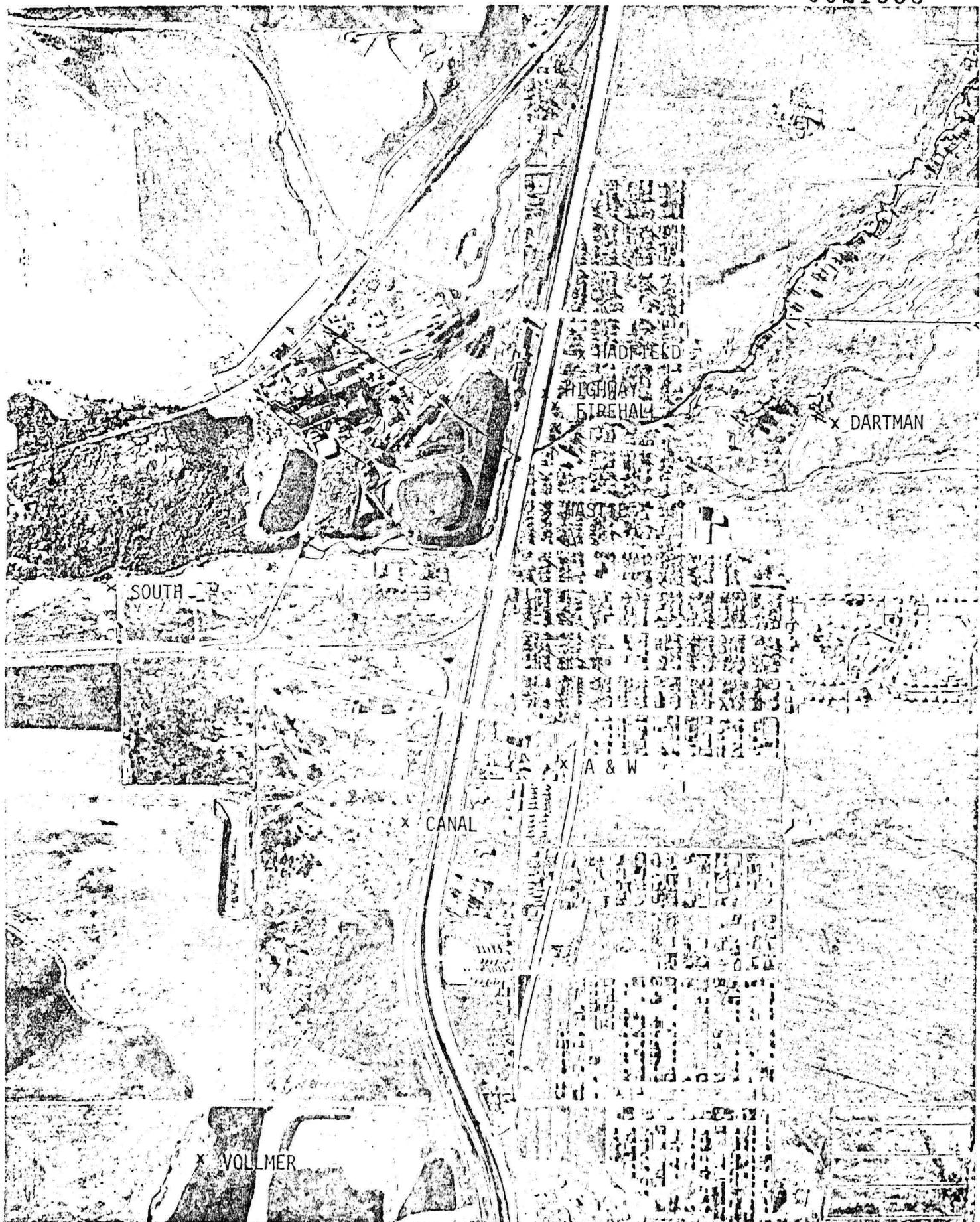
During 1981-82 the State Health Department conducted a study of airborne particles collected at various ambient monitoring locations. See Figures 11 and 12. The study was performed for the Air Quality Bureau by NEA, Inc. of Beaverton, Oregon. Various tables and graphs included here are from a September 1982 draft report.

Respirable and larger particulate were collected at ambient air monitoring locations. These particulates were compared using chemical-mass-balance (CMB) techniques to source particulates, to identify which sources contribute both mass and lead concentrations at each monitoring location. More than 85 sources were uniquely characterized in the rather large study, including: ore storage piles; roads and parking lots; soils; slag, coal and coke piles; railroad tracks; blending buildings; zinc and lead plants including furnace areas, baghouses, scrubbers and stacks; dressing and sinter operations; etc. The following non-industrial sources of particulates were also sampled: highways and roads; streets and parking lots; cultivated and non-cultivated fields.

A computer program apportioned the ambient particulates to identify major source contributors. The attached raw data printouts (Figures 13-21) show, for the Highway and Firehall sites, examples of the particles as sampled by a lo-vol device using teflon filter media. The collected matter is in the 0-30 micron size range for the lo-vol sampler.

Consider Figure 13 for the Highway site. Measured field concentrations are shown in the lower left area; for example, lead, cadmium and arsenic were 3.913, 0.340, and 0.616 ug/m<sup>3</sup> respectively. Below the headings, at the top, are those sources which contributed the measured ambient mass of 137.3 ug/m<sup>3</sup> on November 12, 1981. The sources, which vary from day to day, accounted for 121.130 of 137.3 ug/m<sup>3</sup> or 88.211 percent. The unaccounted for mass is probably carbonaceous material.





EAST HELENA AMBIENT AIR MONITORING LOCATIONS USED FOR 1981-82 SOURCE IDENTIFICATION STUDY. Particulate sampling equipment included Hi-vols, Lo-vols, and Dichotomous monitors.

0-30 micron size

DEQ RESULTS FOR CMB # HT361

PARTICULATE FRACTION

AMPLING DATE: 811112 SITE CODE: 06

AMPLING DURATION: 24 HRS. WITH START HOUR: 0

FE: HIGHWAY ✓

EFFECTIVE VARIANCE FITTING. REDUCED CHI SQUARE: 0.529 D OF F: 5

DE SOURCE FLG UG/M3 %

1	TRANS	*	1.166+- 0.541	0.849+- 0.404
4	GEO-K	*	56.482+- 5.419	41.132+- 5.759
7	LIME	*	1.143+- 1.797	0.656+- 1.312
8	SLAGM	*	2.697+- 1.396	1.964+- 1.036
6	DRBLD	*	1.342+- 0.550	0.977+- 0.413
3	BLFUP	*	1.974+- 0.578	1.438+- 0.445
4	ZHKLD	*	1.483+- 0.523	1.080+- 0.397
5	CUKST	*	53.158+- 7.566	38.711+- 6.778
9	DRCOM	*	1.685+- 2.394	0.874+- 1.748

TOTAL: 121.130+- 9.936 88.211+-11.545

CMB fit

PECIE CODE	Ambient MEAS.	TOTAL UG/M3	SUSPENDED PERCENT	PARTICULATE CALC UG/M3	RATIO = $\frac{\text{calc.}}{\text{meas.}}$	
1 AL *	3.150+- 0.368	2.294	3.389+- 0.311	1.076+-0.145	AL	
2 SI *	11.001+- 1.239	8.011	11.765+- 1.112	1.069+-0.148	SI	
3 P	0.234+- 0.030	0.170	0.223+- 0.014	0.955+-0.082	P	
4 S *	3.210+- 0.423	2.337	3.681+- 0.264	1.147+-0.125	S	
5 CL	0.368+- 0.065	0.268	1.231+- 0.115	3.348+-1.089	CL	
6 K *	0.886+- 0.107	0.645	0.834+- 0.067	0.942+-0.104	K	
7 CA *	3.466+- 0.393	2.524	3.449+- 0.251	0.995+-0.102	CA	
8 TI *	0.208+- 0.026	0.151	0.191+- 0.017	0.917+-0.112	TI	
9 V	0.024+- 0.005	0.017	0.014+- 0.001	0.573+-0.058	V	
10 CR	0.034+- 0.006	0.025	0.027+- 0.002	0.797+-0.071	CR	
11 MN *	0.110+- 0.014	0.080	0.113+- 0.010	1.033+-0.128	MN	
12 FE *	3.179+- 0.359	2.315	3.023+- 0.259	0.951+-0.113	FE	
13 HI	0.165+- 0.021	0.120	0.143+- 0.011	0.867+-0.090	HI	
14 CU *	37.395+- 4.188	27.232	33.647+- 2.918	0.900+-0.105	CU	
15 ZN *	2.349+- 0.266	1.711	2.353+- 0.148	1.001+-0.089	ZN	
16 AS *	0.616+- 0.079	0.449	0.620+- 0.077	1.007+-0.178	AS	
17 SE	0.016+- 0.004	0.012	0.015+- 0.001	0.969+-0.119	SE	
18 BR *	0.116+- 0.014	0.085	0.118+- 0.031	1.011+-0.377	BR	
19 SR	0.049+- 0.007	0.036	0.036+- 0.004	0.729+-0.092	SR	
20 PD	0.025+- 0.010	0.018	0.031+- 0.005	1.256+-0.299	PD	
21 AG	0.061+- 0.017	0.045	0.035+- 0.011	0.570+-0.212	AG	
22 CD *	0.340+- 0.051	0.248	0.342+- 0.023	1.005+-0.097	CD	
23 IN	< 0.020	---	0.008+- 0.004	0.000+-0.000	IN	
24 SH	0.105+- 0.028	0.076	0.071+- 0.012	0.673+-0.138	SH	
25 SB	0.125+- 0.053	0.091	0.231+- 0.095	1.853+-1.600	SB	
26 BA	< 0.099	---	0.081+- 0.050	2.773+-5.019	BA	
27 HG	0.021+- 0.007	0.015	0.012+- 0.003	0.568+-0.141	HG	
28 PB *	3.913+- 0.440	2.849	3.727+- 0.339	0.953+-0.120	PB	

AS. AMB. MASS (UG/M3): 137.3 ✓

\* - FITTING ELEMENT

CMB calc.

The abbreviated sources are as follows:

Trans - (auto-exhaust)  
Geo-K - (4-lane highway)  
Lime - (Lime)  
Slag-M - (ASARCO slag pile)  
DRBLD - (ASARCO dross building)  
BLFUP - (ASARCO blast furnace upset)  
ZnKLD - (CHEMET zinc kiln discharge)  
CuKST - (CHEMET copper kiln stack)  
ORCOM - (ASARCO ore composite)

The CMB model accounts for nearly all the observed mass on November 12. The four-lane highway, for example, contributes 41.132 percent of the accounted for mass. The CMB fit (reduced chi square or goodness of fit = 0.529) is excellent. The lower the reduced chi square value, the more excellent the fit.

Figure 15 shows high zinc and lead concentrations. Figure 16 shows high lead, copper and zinc concentrations. Figure 21 shows 32.9 percent of the total measured mass to be copper. These figures are included to illustrate case day variations.

Our study found co-collected lo-vol (0-30 $\mu$ ) to hi-vol (0-100 $\mu$ ) particulate comparisons to yield the following:

Table 2

Ratio: Lo-vol/Hi-vol co-collected data

Sample Set	Mass	Pb	Cd	Cu	Zn	As
Hadfield 4th quarter 1981 28 sample days	.66	.69	1.05	.66	1.06	1.33
Hastie 4th quarter 1981 23 sample days	.65	.71	1.05	.56	.96	1.32

Intrepreting Table 2 we found lead to be mostly large (15-100  $\mu$ ) in size while more than half the arsenic and cadmium concentrations were in the less than 2.5  $\mu$  size category.

IBDEQ RESULTS FOR CMB # HT018

TOTAL PARTICULATE FRACTION

SAMPLING DATE: 810205 SITE CODE: 03

SAMPLING DURATION: 24 HRS. WITH START HOUR: 0

TYPE: FIREHALL

EFFECTIVE VARIANCE FITTING. REDUCED CHI SQUARE: 5.362 D OF F: 6  
DOE SOURCE FLG UG/M3 %

1	TRANS	*	2.543+- 1.071	1.820+- 0.788
5	GEO-L	*	43.213+- 4.277	30.914+- 4.394
6	SLAGC	*	-0.932+- 4.390	1.571+- 3.141
4	HDBLD	*	21.049+- 6.452	15.058+- 4.864
6	DRBLD	*	4.156+- 0.964	2.973+- 0.754
9	BLFUP	*	6.196+- 1.376	4.432+- 1.083
4	ZHKLD	*	7.510+- 1.477	5.373+- 1.190
5	CUKST	*	19.436+- 3.017	13.904+- 2.582
<hr/>				
TOTAL:		103.171+- 9.718	73.808+-10.246	

PECIE		TOTAL DOE MEAS.	SUSPENDED PERCENT	PARTICULATE CALC.	UG/M3	RATIO
1	AL *	3.207+- 0.362	2.294	3.693+- 0.351	1.152+-0.167	AL
2	SI *	11.051+- 1.233	7.906	12.838+- 1.255	1.162+-0.174	SI
3	P	0.363+- 0.042	0.260	0.246+- 0.012	0.677+-0.041	P
4	S *	6.403+- 0.831	4.581	3.228+- 0.264	0.504+-0.046	S
5	CL	0.104+- 0.048	0.074	0.772+- 0.076	7.427+-5.471	CL
6	K *	1.256+- 0.143	0.899	0.977+- 0.073	0.778+-0.074	K
7	CA *	3.591+- 0.404	2.569	2.142+- 0.145	0.597+-0.047	CA
8	TI *	0.199+- 0.023	0.143	0.199+- 0.017	0.998+-0.122	TI
9	V	0.014+- 0.003	0.010	0.016+- 0.001	1.099+-0.145	V
10	CR	0.026+- 0.004	0.019	0.053+- 0.004	2.042+-0.343	CR
11	MN *	0.130+- 0.015	0.093	0.150+- 0.011	1.153+-0.130	MN
12	FE *	3.744+- 0.421	2.679	3.909+- 0.279	1.044+-0.108	FE
13	NI	0.083+- 0.011	0.059	0.086+- 0.005	1.033+-0.080	NI
14	CU *	11.179+- 1.252	7.997	12.432+- 1.061	1.112+-0.142	CU
15	ZH *	6.749+- 0.756	4.823	6.969+- 0.493	1.033+-0.106	ZH
16	AS *	1.566+- 0.183	1.120	1.548+- 0.129	0.989+-0.115	AS
17	SE	0.037+- 0.006	0.026	0.050+- 0.003	1.368+-0.150	SE
18	BR *	0.196+- 0.023	0.140	0.204+- 0.066	1.039+-0.488	BR
19	SR	0.048+- 0.007	0.034	0.060+- 0.004	1.255+-0.139	SR
20	PD	0.044+- 0.011	0.031	0.082+- 0.006	1.866+-0.267	PD
21	AG	0.066+- 0.015	0.047	0.090+- 0.006	1.360+-0.157	AG
22	CD *	0.812+- 0.098	0.581	0.905+- 0.066	1.115+-0.122	CD
23	IN	0.028+- 0.016	0.020	0.016+- 0.004	0.568+-0.163	IN
24	SN	0.293+- 0.042	0.210	0.168+- 0.010	0.572+-0.038	SN
25	SB	0.498+- 0.076	0.356	0.404+- 0.028	0.811+-0.074	SB
26	BA	0.250+- 0.090	0.179	0.079+- 0.027	0.314+-0.112	BA
27	HG	0.032+- 0.009	0.023	0.026+- 0.003	0.795+-0.111	HG
28	PB *	9.728+- 1.090	6.959	10.039+- 0.569	1.032+-0.084	PB
<hr/>						

AS. AMB. MASS (UG/M3): 139.8

\* - FITTING ELEMENT

Figure 14

BDEQ RESULTS FOR CMB # HT019

TAL PARTICULATE FRACTION

AMPLING DATE: 810209 SITE CODE: 03

AMPLING DURATION: 24 HRS. WITH START HOUR: 0

TE: FIREHALL

EFFECTIVE VARIANCE FITTING. REDUCED CHI SQUARE: 5.026 D OF F: 6

ODE SOURCE FLG UG/M3 %

1	TRANS	*	1.271+- 0.558	1.561+- 0.703
5	GEO-L	*	10.616+- 1.422	13.036+- 2.194
6	SLAGC	*	-0.060+- 2.020	1.240+- 2.481
4	HOBBLD	*	5.367+- 3.308	6.590+- 4.117
6	DRBLD	*	1.515+- 0.568	1.860+- 0.723
9	BLFUP	*	4.967+- 0.847	6.098+- 1.212
4	ZHKLD	*	29.262+- 3.777	35.932+- 5.911
5	CUKST	*	4.556+- 0.770	5.594+- 1.104
<hr/>				
TOTAL:		57.494+- 5.767	70.597+-10.098	

PECIE CODE	TOTAL MEAS.	SUSPENDED UG/M3	PARTICULATE PERCENT	CALC. UG/M3	RATIO	
1 AL *	1.015+- 0.117	1.246	1.033+- 0.087	1.017+-0.123	AL	
2 SI *	3.221+- 0.362	3.955	3.346+- 0.309	1.039+-0.138	SI	
3 P	0.243+- 0.028	0.298	0.136+- 0.007	0.561+-0.033	P	
4 S *	4.724+- 0.628	5.801	2.187+- 0.182	0.463+-0.044	S	
5 CL	< 0.038	---	0.447+- 0.054	9.999+-9.999	CL	
6 K *	0.512+- 0.060	0.628	0.464+- 0.026	0.906+-0.070	K	
7 CA *	1.021+- 0.116	1.254	0.639+- 0.038	0.626+-0.044	CA	
8 TI *	0.053+- 0.007	0.065	0.060+- 0.004	1.138+-0.124	TI	
9 V	0.008+- 0.002	0.010	0.007+- 0.001	0.890+-0.116	V	
10 CR	0.012+- 0.002	0.015	0.019+- 0.001	1.551+-0.172	CR	
11 MN *	0.039+- 0.005	0.049	0.046+- 0.003	1.158+-0.114	MN	
12 FE *	1.102+- 0.125	1.353	1.128+- 0.070	1.024+-0.091	FE	
13 HI	0.052+- 0.007	0.063	0.053+- 0.003	1.030+-0.092	HI	
14 CU *	2.914+- 0.327	3.578	3.051+- 0.249	1.047+-0.124	CU	
15 ZN *	16.269+- 1.821	19.977	19.287+- 1.849	1.186+-0.176	ZN	
16 AS *	0.924+- 0.112	1.134	0.925+- 0.059	1.002+-0.091	AS	
17 SE	0.019+- 0.004	0.024	0.119+- 0.011	6.186+-3.607	SE	
18 BR *	0.120+- 0.014	0.148	0.129+- 0.033	1.073+-0.405	BR	
19 SR	0.015+- 0.004	0.019	0.018+- 0.002	1.195+-0.167	SR	
20 PD	0.046+- 0.010	0.057	0.046+- 0.004	0.984+-0.113	PD	
21 AG	0.063+- 0.014	0.078	0.039+- 0.003	0.615+-0.063	AG	
22 CD *	0.521+- 0.065	0.640	0.603+- 0.051	1.158+-0.150	CD	
23 IH	0.072+- 0.018	0.089	0.015+- 0.005	0.210+-0.068	IH	
24 SH	0.262+- 0.038	0.322	0.177+- 0.013	0.673+-0.059	SH	
25 SB	0.212+- 0.045	0.260	0.236+- 0.012	1.112+-0.126	SB	
26 BA	0.285+- 0.084	0.350	0.028+- 0.024	0.098+-0.084	BA	
27 HG	0.040+- 0.009	0.049	0.026+- 0.003	0.643+-0.093	HG	
28 PB *	7.885+- 0.884	9.682	7.359+- 0.423	0.933+-0.073	PB	

EAS. AMB. MASS (UG/M3): 81.4

\* - FITTING ELEMENT

## 3DEQ RESULTS FOR CMB # HT036

TAL PARTICULATE FRACTION

IMPLING DATE: 810203 SITE CODE: 03

IMPLING DURATION: 24 HRS. WITH START HOUR: 0

EVE: FIREHALL

EFFECTIVE VARIANCE FITTING. REDUCED CHI SQUARE: 2.719 D OF F: 6

3DE SOURCE FLG UG/M3 %

1	TRANS	*	2.475+- 1.074	1.542+- 0.687
5	GEO-L	*	32.740+- 4.649	20.405+- 3.567
3	SLAGC	*	7.495+- 7.591	2.378+- 4.755
4	NDBLD	*	41.715+-12.411	25.998+- 8.177
5	DR8LD	*	2.896+- 1.098	1.805+- 0.709
3	BLFUP	*	17.525+- 3.405	10.922+- 2.397
4	ZNKLD	*	6.853+- 1.968	4.271+- 1.301
5	CUKST	*	16.238+- 2.789	10.120+- 2.021
<hr/>				
TOTAL: 127.938+-16.090 79.735+-12.910				

SPECIE	TOTAL	SUSPENDED	PARTICULATE		
3DE	MEAS.	UG/M3	PERCENT	CALC. UG/M3	RATIO

1	AL	*	3.204+- 0.362	1.997	3.219+- 0.270	1.005+-0.120	AL
2	SI	*	10.749+- 1.205	6.699	11.304+- 0.976	1.052+-0.132	SI
3	P		0.502+- 0.057	0.313	0.371+- 0.019	0.740+-0.047	P
4	S	*	9.321+- 1.260	5.809	5.525+- 0.541	0.593+-0.068	S
5	CL	<	0.067	---	1.191+- 0.180	0.000+-0.000	CL
6	K	*	1.115+- 0.129	0.695	1.106+- 0.063	0.932+-0.080	K
7	CA	*	3.891+- 0.438	2.425	3.109+- 0.177	0.799+-0.058	CA
8	TI	*	0.212+- 0.025	0.132	0.209+- 0.014	0.983+-0.092	TI
9	V		0.024+- 0.004	0.015	0.020+- 0.002	0.853+-0.105	V
10	CR		0.034+- 0.005	0.021	0.098+- 0.008	2.898+-0.686	CR
11	MN	*	0.336+- 0.038	0.209	0.285+- 0.020	0.843+-0.079	MN
12	FE	*	6.032+- 0.677	3.760	7.253+- 0.441	1.202+-0.114	FE
13	NI		0.105+- 0.013	0.065	0.106+- 0.005	1.014+-0.072	NI
14	CU	*	10.673+- 1.196	6.652	11.142+- 0.891	1.044+-0.121	CU
15	ZH	*	9.365+- 1.049	5.837	9.380+- 0.533	1.002+-0.080	ZH
16	AS	*	1.258+- 0.221	1.158	1.839+- 0.111	0.990+-0.084	AS
17	SE		0.039+- 0.007	0.024	0.065+- 0.004	1.666+-0.204	SE
18	BR	*	0.222+- 0.026	0.138	0.222+- 0.065	1.000+-0.415	BR
19	SR		0.147+- 0.018	0.092	0.105+- 0.008	0.710+-0.064	SR
20	PD		0.102+- 0.017	0.064	0.104+- 0.006	1.021+-0.084	PD
21	AG		0.102+- 0.021	0.063	0.148+- 0.011	1.451+-0.182	AG
22	CD	*	2.204+- 0.255	1.374	2.216+- 0.182	1.005+-0.117	CD
23	IH		0.074+- 0.023	0.046	0.020+- 0.004	0.265+-0.056	IH
24	SH		0.272+- 0.044	0.169	0.240+- 0.013	0.882+-0.064	SH
25	SB		0.426+- 0.080	0.266	0.628+- 0.044	1.473+-0.185	SB
26	BA	<	0.112	---	0.155+- 0.027	2.726+-1.385	BA
27	HG		0.039+- 0.012	0.025	0.039+- 0.005	0.975+-0.190	HG
28	PB	*	16.338+- 1.830	10.182	19.445+- 1.220	1.190+-0.116	PB

3S. AMB. MASS (UG/M3): 160.5

&gt; - FITTING ELEMENT

Figure 16

## BDEQ RESULTS FOR CMB # HT037

TOTAL PARTICULATE FRACTION

SAMPLING DATE: 810302 SITE CODE: 03

SAMPLING DURATION: 24 HRS. WITH START HOUR: 0

TE: FIREBALL

EFFECTIVE VARIANCE FITTING. REDUCED CHI SQUARE: 1.708 D OF F: 6  
CODE SOURCE FLG UG/M3 %

1	TRANS	*	1.430+- 0.608	1.641+- 0.717
5	GEO-L	*	31.678+- 3.127	36.346+- 5.159
6	SLAGC	*	2.952+- 2.651	3.387+- 3.061
4	NDBLD	*	10.465+- 3.616	12.008+- 4.326
6	DRBLD	*	3.285+- 0.701	3.769+- 0.892
8	BLFUP	*	2.570+- 0.732	2.949+- 0.892
4	ZHKLD	*	5.003+- 1.011	5.740+- 1.299
5	CUKST	*	19.417+- 2.844	22.278+- 3.976
<hr/>				
TOTAL: 76.799+- 6.355 88.118+-11.572				

SPECIE TOTAL SUSPENDED PARTICULATE  
CODE MEAS. UG/M3 PERCENT CALC. UG/M3 RATIO

1	AL	*	2.677+- 0.302	3.072	2.819+- 0.258	1.053+-0.140	AL
2	SI	*	9.272+- 1.039	10.639	9.867+- 0.919	1.064+-0.145	SI
3	P	0.204+- 0.024	0.235	0.166+- 0.008	0.814+-0.053	P	
4	S	*	2.812+- 0.388	3.233	2.160+- 0.151	0.767+-0.068	S
5	CL	0.145+- 0.033	0.166	0.585+- 0.049	4.040+-1.414	CL	
6	K	*	0.797+- 0.091	0.914	0.703+- 0.053	0.883+-0.089	K
7	CA	*	2.273+- 0.256	2.608	1.673+- 0.102	0.736+-0.056	CA
8	TI	*	0.139+- 0.017	0.160	0.151+- 0.013	1.083+-0.133	TI
9	V	0.018+- 0.003	0.020	0.012+- 0.001	0.671+-0.063	V	
10	CR	0.013+- 0.002	0.015	0.034+- 0.002	2.537+-0.424	CR	
11	MN	*	0.111+- 0.013	0.128	0.109+- 0.007	0.981+-0.082	MN
12	FE	*	2.811+- 0.316	3.226	3.146+- 0.187	1.119+-0.100	FE
13	HI	0.070+- 0.009	0.080	0.069+- 0.004	0.987+-0.084	HI	
14	CU	*	10.776+- 1.207	12.365	11.847+- 1.056	1.099+-0.146	CU
15	ZN	*	4.675+- 0.524	5.364	4.726+- 0.327	1.011+-0.100	ZN
16	AS	*	1.117+- 0.129	1.282	1.104+- 0.100	0.988+-0.126	AS
17	SE	0.018+- 0.003	0.021	0.032+- 0.002	1.777+-0.238	SE	
18	BR	*	0.118+- 0.014	0.136	0.120+- 0.037	1.013+-0.449	BR
19	SR	0.053+- 0.007	0.061	0.037+- 0.002	0.699+-0.053	SR	
20	PD	0.037+- 0.009	0.042	0.056+- 0.004	1.512+-0.206	PD	
21	AG	0.034+- 0.012	0.039	0.054+- 0.004	1.616+-0.203	AG	
22	CD	*	0.420+- 0.054	0.482	0.431+- 0.028	1.025+-0.096	CD
23	IN	0.028+- 0.014	0.032	0.012+- 0.003	0.407+-0.108	IN	
24	SN	0.131+- 0.025	0.151	0.109+- 0.007	0.828+-0.070	SN	
25	SB	0.210+- 0.046	0.241	0.253+- 0.018	1.207+-0.136	SB	
26	BA	0.108+- 0.078	0.124	0.055+- 0.022	0.505+-0.227	BA	
27	HG	0.024+- 0.006	0.028	0.017+- 0.002	0.696+-0.083	HG	
28	PB	*	5.083+- 0.570	5.832	5.415+- 0.282	1.065+-0.081	PB
<hr/>							

AS. AMB. MASS (UG/M3): 87.2

\* - FITTING ELEMENT

Figure 17

DEQ RESULTS FOR CMB # HT041

TOTAL PARTICULATE FRACTION

AMPLING DATE: 810308 SITE CODE: 03

AMPLING DURATION: 24 HRS. WITH START HOUR: 0

E: FIREHALL

EFFECTIVE VARIANCE FITTING. REDUCED CHI SQUARE: 4.032 D OF F: 6

IDE SOURCE FLG UG/M3 %

1	TRANS	*	1.325+- 0.558	2.646+- 1.147
2	GEO-L	*	22.330+- 2.139	44.600+- 6.240
3	SLAGC	*	1.121+- 1.812	1.813+- 3.627
4	NDBLD	*	4.073+- 2.643	8.134+- 5.344
5	DRBLD	*	2.699+- 0.578	5.390+- 1.279
6	BLFUP	*	3.660+- 0.723	7.310+- 1.626
7	ZHKLD	*	5.130+- 0.893	10.245+- 2.067
8	CUKST	*	-0.680+- 0.213	0.224+- 0.448
<hr/>				
TOTAL:		39.658+- 4.106	79.207+-11.511	

SPECIE IDE	TOTAL MEAS.	UG/M3	SUSPENDED	PARTICULATE	RATIO
			PERCENT	CALC. UG/M3	
1 AL *	1.843+- 0.209	3.682	1.897+- 0.181	1.029+-0.141	AL
2 SI *	6.350+- 0.712	12.682	6.730+- 0.647	1.060+-0.148	SI
3 P	0.160+- 0.019	0.320	0.094+- 0.005	0.585+-0.039	P
4 S *	2.185+- 0.299	4.365	1.046+- 0.089	0.479+-0.045	S
5 CL	0.089+- 0.026	0.178	0.187+- 0.037	2.091+-0.969	CL
6 K *	0.526+- 0.061	1.050	0.484+- 0.038	0.921+-0.098	K
7 CA *	1.388+- 0.157	2.772	0.920+- 0.067	0.663+-0.058	CA
8 TI *	0.088+- 0.011	0.175	0.099+- 0.009	1.134+-0.152	TI
9 V	0.009+- 0.002	0.018	0.008+- 0.001	0.862+-0.092	V
0 CR	0.008+- 0.002	0.017	0.016+- 0.001	1.888+-0.235	CR
1 MN *	0.057+- 0.007	0.114	0.057+- 0.003	0.994+-0.086	MN
2 FE *	1.536+- 0.173	3.068	1.737+- 0.113	1.131+-0.111	FE
3 HI	0.016+- 0.003	0.032	0.019+- 0.001	1.201+-0.089	HI
4 CU *	0.425+- 0.055	0.970	0.495+- 0.073	1.020+-0.216	CU
5 ZH *	4.012+- 0.450	8.025	4.127+- 0.327	1.027+-0.117	ZH
6 AS *	0.923+- 0.107	1.843	0.898+- 0.082	0.973+-0.124	AS
7 SE	0.018+- 0.003	0.035	0.028+- 0.002	1.558+-0.211	SE
8 BR *	0.102+- 0.012	0.205	0.104+- 0.034	1.020+-0.481	BR
9 SR	0.024+- 0.004	0.049	0.020+- 0.001	0.803+-0.065	SR
0 PD	0.012+- 0.006	0.023	0.042+- 0.003	3.649+-1.042	PD
1 AG	0.030+- 0.011	0.060	0.034+- 0.002	1.140+-0.112	AG
2 CD *	0.419+- 0.054	0.837	0.457+- 0.038	1.092+-0.133	CD
3 IH	0.031+- 0.014	0.062	0.010+- 0.002	0.311+-0.071	IH
4 SN	0.086+- 0.021	0.171	0.085+- 0.005	0.996+-0.080	SN
5 SB	0.193+- 0.044	0.386	0.167+- 0.013	0.865+-0.088	SB
6 BA	< 0.073	---	0.032+- 0.011	1.201+-0.621	BA
7 HG	0.025+- 0.006	0.050	0.011+- 0.001	0.452+-0.047	HG
8 PB *	3.677+- 0.413	7.344	4.077+- 0.203	1.109+-0.082	PB

S. AMB. MASS (UG/M3): 50.1

- FITTING ELEMENT

## IBDEQ RESULTS FOR CMB # HT043

TOTAL PARTICULATE FRACTION

SAMPLING DATE: 810311 SITE CODE: 03

SAMPLING DURATION: 22 HRS. WITH START HOUR: 0

TE: FIREBALL

EFFECTIVE VARIANCE FITTING. REDUCED CHI SQUARE: 2.643 D OF F: 6

ODE SOURCE FLG UG/M3 %

1	TRANS	*	2.433+- 1.024	2.690+- 1.165
5	GEO-L	*	38.720+- 3.811	42.815+- 6.068
6	SLAGC	*	-3.082+- 4.075	2.260+- 4.520
4	HDBLD	*	18.447+- 6.247	20.398+- 7.214
6	DRBLD	*	5.010+- 1.101	5.540+- 1.342
8	BLFUP	*	7.895+- 1.542	8.730+- 1.924
4	ZHKLD	*	7.944+- 1.483	8.784+- 1.863
5	CUKST	*	7.362+- 1.395	8.140+- 1.751
<hr/>				
TOTAL:		84.729+- 8.884	93.689+-13.704	

PECIE ODE	TOTAL MEAS. UG/M3	SUSPENDED PERCENT	PARTICULATE CALC. UG/M3	RATIO
--------------	----------------------	----------------------	----------------------------	-------

1 AL *	2.912+- 0.330	3.227	3.202+- 0.315	1.097+-0.160	AL
2 SI *	10.365+- 1.162	11.461	11.151+- 1.125	1.076+-0.159	SI
3 P	0.274+- 0.032	0.303	0.215+- 0.011	0.785+-0.052	P
4 S *	4.558+- 0.665	5.040	2.759+- 0.248	0.605+-0.064	S
5 CL	< 0.043	---	0.576+- 0.082	9.999+-9.999	CL
6 K *	1.013+- 0.116	1.120	0.878+- 0.066	0.867+-0.086	K
7 CA *	2.467+- 0.278	2.728	1.707+- 0.130	0.692+-0.064	CA
8 TI *	0.161+- 0.019	0.172	0.172+- 0.015	1.067+-0.140	TI
9 V	0.021+- 0.003	0.023	0.014+- 0.001	0.638+-0.071	V
10 CR	0.022+- 0.003	0.024	0.044+- 0.003	2.006+-0.351	CR
11 MN *	0.107+- 0.012	0.118	0.120+- 0.010	1.117+-0.140	MN
12 FE *	2.035+- 0.326	3.201	3.034+- 0.255	1.048+-0.128	FE
13 NI	0.053+- 0.008	0.065	0.059+- 0.003	0.995+-0.064	NI
14 CU *	5.474+- 0.614	6.053	5.698+- 0.416	1.041+-0.110	CU
15 ZH *	6.722+- 0.753	7.433	6.901+- 0.522	1.027+-0.111	ZH
16 AS *	1.772+- 0.205	1.960	1.755+- 0.154	0.990+-0.122	AS
17 SE	0.030+- 0.005	0.034	0.051+- 0.003	1.683+-0.216	SE
18 BR *	0.106+- 0.022	0.206	0.193+- 0.063	1.039+-0.492	BR
19 SR	0.049+- 0.007	0.054	0.052+- 0.004	1.075+-0.112	SR
20 PD	0.038+- 0.010	0.042	0.090+- 0.006	2.384+-0.421	PD
21 AG	0.083+- 0.016	0.092	0.089+- 0.006	1.055+-0.100	AG
22 CD *	0.348+- 0.113	1.048	1.052+- 0.082	1.110+-0.130	CD
23 IH	0.029+- 0.018	0.032	0.018+- 0.004	0.626+-0.155	IH
24 SH	0.182+- 0.032	0.201	0.176+- 0.010	0.369+-0.074	SH
25 SB	0.460+- 0.073	0.509	0.401+- 0.029	0.871+-0.083	SB
26 BA	0.166+- 0.093	0.184	0.069+- 0.020	0.417+-0.133	BA
27 HG	0.058+- 0.011	0.064	0.025+- 0.003	0.424+-0.050	HG
28 PB *	9.887+- 1.108	10.933	10.145+- 0.561	1.026+-0.081	PB

AS. AMB. MASS (UG/M3): 90.4

\* - FITTING ELEMENT

Figure 19

0021564

PAGE 0014

## BDEQ RESULTS FOR CMB # HT050

## TOTAL PARTICULATE FRACTION

AMPLING DATE: 210314 SITE CODE: 03

AMPLING DURATION: 24 HRS. WITH START HOUR: 0

TE: FIREHALL

EFFECTIVE VARIANCE FITTING. REDUCED CHI SQUARE: 2.759 D OF F: 6  
ODE SOURCE FLG UG/M3 %

1	TRANS	*	1.023+- 0.440	1.411+- 0.624
5	GEO-L	*	28.347+- 2.999	39.087+- 5.743
6	SLACC	*	9.936+- 2.561	13.701+- 3.798
4	HOBBLD	*	4.237+- 2.986	5.843+- 4.161
6	DRBLD	*	1.826+- 0.457	2.517+- 0.680
8	BLFUP	*	3.766+- 0.793	5.193+- 1.215
4	ZHKLG	*	2.575+- 0.747	3.551+- 1.092
5	CUKST	*	4.996+- 0.933	6.889+- 1.465
<hr/>				
TOTAL: 56.707+- 5.189 78.192+-10.714				

PECIE ODE	TOTAL MEAS.	SUSPENDED UG/M3	PARTICULATE PERCENT	CALC. UG/M3	RATIO
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1	AL *	2.587+- 0.292	3.567	2.693+- 0.233	1.041+-0.130	AL	
2	SI *	9.132+- 1.023	12.592	9.733+- 0.933	1.066+-0.133	SI	
3	P	0.163+- 0.019	0.225	0.127+- 0.007	0.776+-0.052	P	
4	S	*	2.436+- 0.324	3.359	1.432+- 0.993	0.582+-0.044	S
5	CL	0.111+- 0.028	0.153	0.310+- 0.040	2.789+-1.056	CL	
6	K	*	0.761+- 0.087	1.043	0.651+- 0.048	0.856+-0.083	K
7	CA	*	2.210+- 0.249	3.043	1.716+- 0.107	0.776+-0.061	CA
8	TI	*	0.134+- 0.016	0.125	0.149+- 0.012	1.109+-0.128	TI
9	V	0.019+- 0.003	0.026	0.012+- 0.001	0.632+-0.053	V	
10	CR	0.016+- 0.003	0.022	0.027+- 0.001	1.670+-0.174	CR	
11	MN	*	0.124+- 0.014	0.170	0.119+- 0.007	0.961+-0.083	MN
12	FE	*	3.365+- 0.378	4.640	3.874+- 0.249	1.151+-0.113	FE
13	HI	0.034+- 0.005	0.047	0.034+- 0.001	0.982+-0.059	HI	
14	CU	*	3.674+- 0.412	5.065	3.879+- 0.283	1.056+-0.112	CU
15	ZH	*	3.449+- 0.387	4.755	3.506+- 0.199	1.017+-0.082	ZH
16	AS	*	0.754+- 0.089	1.040	0.740+- 0.057	0.982+-0.106	AS
17	SE	0.015+- 0.003	0.020	0.019+- 0.001	1.282+-0.127	SE	
18	BR	*	0.090+- 0.011	0.125	0.091+- 0.027	1.000+-0.417	BR
19	SR	0.052+- 0.007	0.072	0.029+- 0.002	0.552+-0.034	SR	
20	PD	0.011+- 0.007	0.015	0.034+- 0.002	3.031+-0.704	PD	
21	AG	0.042+- 0.011	0.057	0.035+- 0.002	0.847+-0.073	AG	
22	CD	*	0.439+- 0.056	0.606	0.473+- 0.039	1.078+-0.130	CD
23	IN	< 0.016	---	0.008+- 0.002	0.923+-0.379	IN	
24	SH	0.283+- 0.040	0.390	0.074+- 0.004	0.261+-0.016	SH	
25	SB	0.200+- 0.046	0.276	0.163+- 0.011	0.814+-0.070	SB	
26	BA	0.163+- 0.085	0.225	0.059+- 0.014	0.356+-0.090	BA	
27	HG	0.032+- 0.007	0.044	0.012+- 0.001	0.367+-0.036	HG	
28	PB	*	3.771+- 0.423	5.200	4.096+- 0.202	1.086+-0.079	PB

(S. AMB. MASS (UG/M3): 72.5

- FITTING ELEMENT

Figure 20  
25.

MBDEQ RESULTS FOR CMB # HT070

TOTAL PARTICULATE FRACTION

SAMPLING DATE: 810407 SITE CODE: 03

SAMPLING DURATION: 24 HRS. WITH START HOUR: 0

SITE: FIREHALL

EFFECTIVE VARIANCE FITTING. REDUCED CHI SQUARE: 1.552 D OF F: 6  
CODE SOURCE FLG UG/M3 %

1	TRANS	*	0.180+- 0.094	0.198+- 0.106
15	GEO-L	*	20.137+- 1.942	22.225+- 3.120
46	SLAGC	*	1.931+- 0.919	2.132+- 1.037
64	NDBLD	*	0.240+- 0.753	0.416+- 0.832
66	DRBLD	*	-0.075+- 0.069	0.038+- 0.076
68	BLFUP	*	0.393+- 0.267	0.433+- 0.298
74	ZHKLD	*	0.526+- 0.207	0.580+- 0.236
75	CUKST	*	37.810+- 4.419	41.730+- 6.473
<b>TOTAL:</b>			<b>61.141+- 4.984</b>	<b>67.481+- 8.810</b>

SPECIE CODE		TOTAL MEAS. UG/M3	SUSPENDED PERCENT	PARTICULATE CALC. UG/M3	RATIO	
1 AL *		1.742+- 0.198	1.922	1.835+- 0.164	1.054+-0.137	AL
2 SI *		5.989+- 0.672	6.610	6.249+- 0.584	1.043+-0.141	SI
3 P		0.129+- 0.016	0.142	0.121+- 0.008	0.942+-0.029	P
4 S *		1.527+- 0.183	1.686	1.991+- 0.171	1.304+-0.184	S
5 CL		2.200+- 0.251	2.429	0.932+- 0.080	0.378+-0.039	CL
6 K *		0.488+- 0.057	0.538	0.440+- 0.034	0.902+-0.095	K
7 CA *		1.012+- 0.115	1.117	1.004+- 0.070	0.992+-0.098	CA
8 TI *		0.096+- 0.012	0.106	0.092+- 0.008	0.965+-0.117	TI
9 V		0.010+- 0.002	0.011	0.006+- 0.001	0.604+-0.062	V
10 CR		0.043+- 0.006	0.047	0.013+- 0.001	0.295+-0.022	CR
11 MN *		0.040+- 0.005	0.044	0.039+- 0.003	0.963+-0.096	MN
12 FE *		1.360+- 0.154	1.501	1.404+- 0.108	1.033+-0.115	FE
13 HI		0.127+- 0.015	0.141	0.084+- 0.008	0.656+-0.072	HI
14 CU *		29.787+- 3.335	32.875	21.079+- 2.048	0.708+-0.084	CU
15 ZH *		0.832+- 0.097	0.918	0.830+- 0.047	0.997+-0.079	ZH
16 AS *		0.045+- 0.014	0.050	0.046+- 0.005	1.003+-0.159	AS
17 SE		0.008+- 0.002	0.009	0.006+- 0.001	0.684+-0.120	SE
18 BR *		0.026+- 0.004	0.028	0.026+- 0.005	1.001+-0.266	BR
19 SR		0.008+- 0.003	0.009	0.014+- 0.001	1.798+-0.290	SR
20 PD		0.009+- 0.008	0.010	0.005+- 0.003	0.600+-0.355	PD
21 AG		0.027+- 0.012	0.030	0.006+- 0.001	0.236+-0.048	AG
22 CD *		0.092+- 0.021	0.101	0.088+- 0.007	0.958+-0.113	CD
23 IN		0.022+- 0.016	0.025	0.000+- 0.002	0.020+-0.072	IN
24 SH		0.107+- 0.024	0.118	0.014+- 0.007	0.135+-0.067	SH
25 SB		0.062+- 0.035	0.069	0.025+- 0.004	0.410+-0.075	SB
26 BA		< 0.083	---	0.021+- 0.033	0.311+-0.508	BA
27 HG		0.007+- 0.003	0.008	0.005+- 0.002	0.703+-0.278	HG
28 PB *		0.787+- 0.090	0.863	0.724+- 0.040	0.996+-0.071	PB

MEAS. AMB. MASS (UG/M3): 90.6

\* - FITTING ELEMENT

Figure 21

Figure 22 shows size breakdowns for co-collected airborne mass measured in East Helena at the indicated monitoring locations. Over 10 percent of the mass is respirable (0-2.5  $\mu$ ) while another 10 plus percent is inhalable (2.5-15  $\mu$ ).

Figure 23 gives co-collected size distributions for ambient lead at the same sampling locations. Roughly 35 percent of the ambient lead concentrations are inhalable in size and about 20 percent are respirable.

Tables 3, 4, 5, and 6 show specific quarterly mean values for mass, lead, cadmium, copper, zinc and arsenic concentrations as well as size distributions based on collocated samplers. Dichotomous samplers gave fine (0-2.5  $\mu$ ) and coarse (2.5-15  $\mu$ ) data while lo-vol and hi-vol samplers collected those concentrations shown.

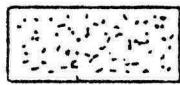
Finally the CMB source apportionment results are graphically presented in Figures 24-30. Source contributions to ambient mass (TSP) and lead concentrations vary with site and quarter; however, it is clear which sources are the overall major contributors. The overall major sources of TSP in the East Helena airshed are: (1) road and soil dust, (2) fugitive ore concentrate and residue emissions, (3) carbonaceous sources (residential wood combustion, coal dust, and unexplained H, O, N and C probably from miscellaneous combustion sources, agricultural materials and pollen), (4) zinc oxide rich material and (5) American Chemet's copper kiln. The overall major sources of lead are: (1) road and soil dust; (2) fugitive ore concentrate and residue emissions; (3) blast furnace upsets; and (4) zinc oxide rich material. The blast furnace upset is a major source of lead even though it is a minor source of TSP due to its high lead content (43 percent).

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>  $\approx$  30 $\mu$



15 -  $\approx$  30 $\mu$



2.5 - 15 $\mu$



< 2.5 $\mu$

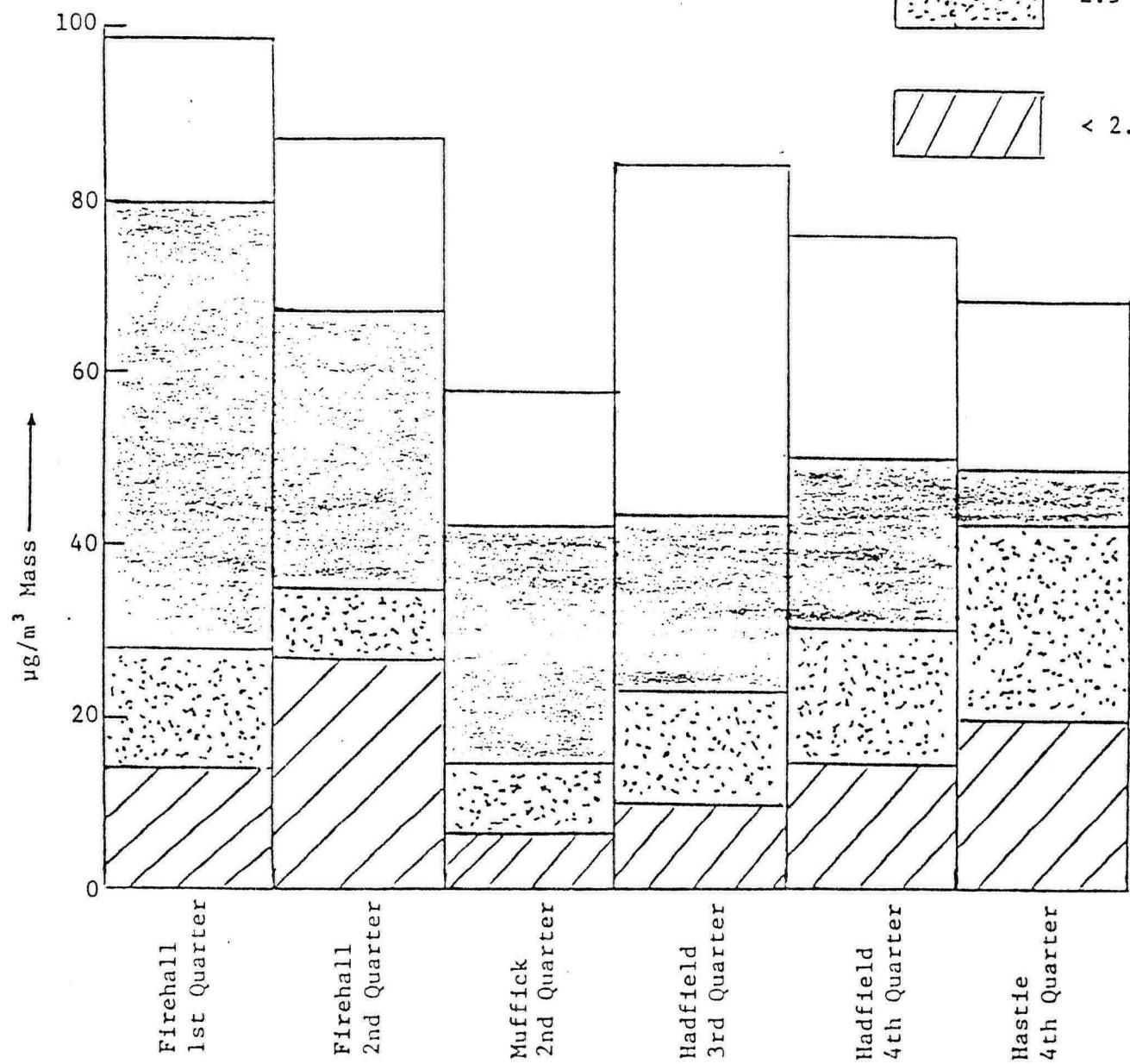


Figure 22 SIZE DISTRIBUTION OF AMBIENT TSP CONTENT BY QUARTER

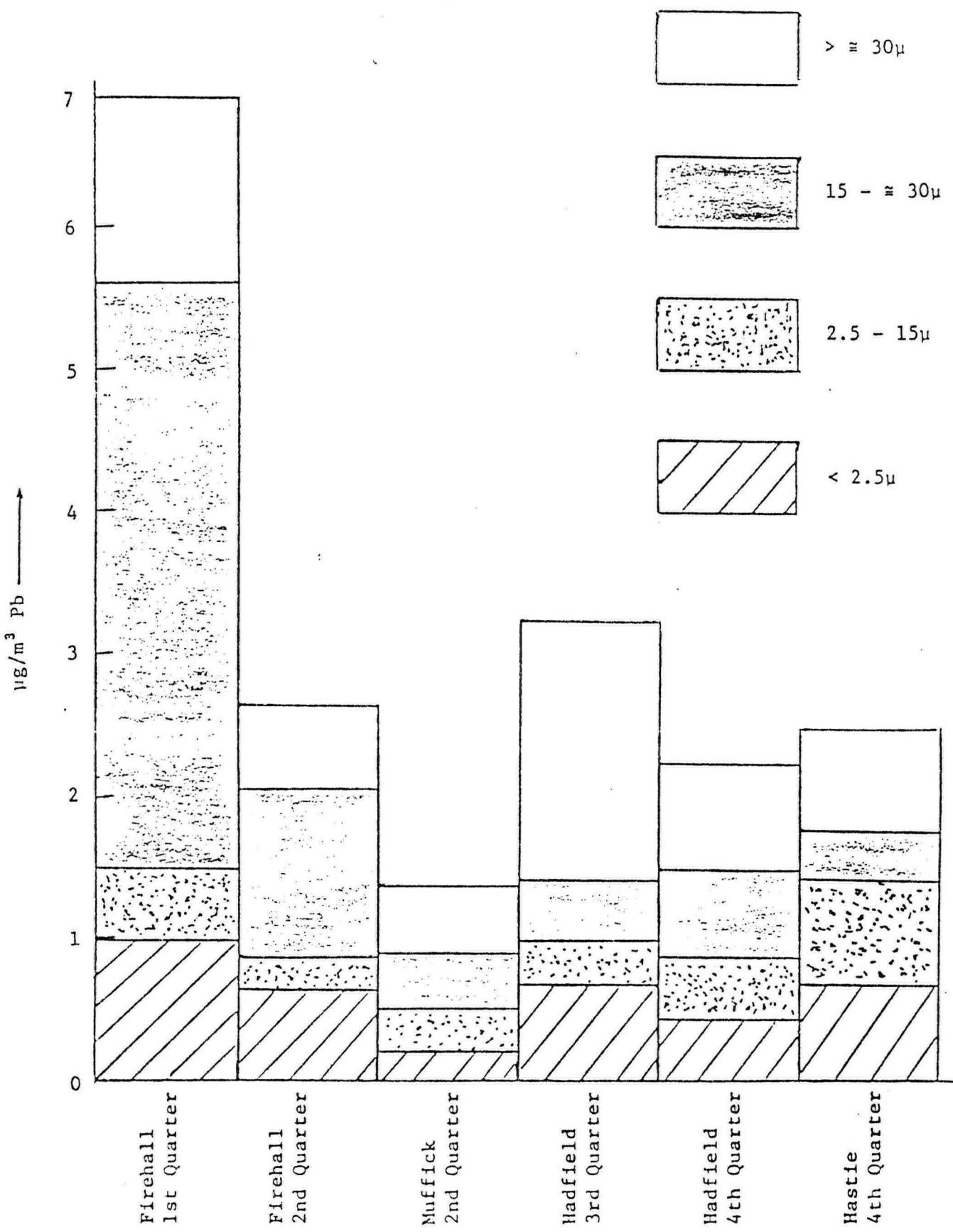


Figure 23 SIZE DISTRIBUTION OF AMBIENT Pb CONTENT BY QUARTER

Table 3

## MASS, Pb and Cd MEAN VALUES AT SITE 3 (Firehall) BY QUARTER

	All Valid Samples Average $\pm$ S.D. ( $\mu\text{g}/\text{m}^3$ )			Co-Collected Samples Average $\pm$ S.D. ( $\mu\text{g}/\text{m}^3$ )		
	Mass	Pb	Cd	Mass	Pb	Cd
<b>1st Quarter</b>						
F	(16) 14.1 $\pm$ 8.5	.85 $\pm$ .84	.121 $\pm$ .141	(13) 13.6 $\pm$ 8.0	.97 $\pm$ .88	.13 $\pm$ .15
C	(16) 13.8 $\pm$ 8.6	.48 $\pm$ .39	.025 $\pm$ .024	(13) 13.4 $\pm$ 7.9	.50 $\pm$ .40	.026 $\pm$ .024
L.V.	(17) 82.4 $\pm$ 34.4	5.41 $\pm$ 3.83	.49 $\pm$ .50	(13) 79.1 $\pm$ 27.7	5.61 $\pm$ 3.90	.52 $\pm$ .55
H.V.	(20) 102 $\pm$ 50	6.20 $\pm$ 4.26		(13) 98 $\pm$ 30	6.89 $\pm$ 4.33	
H.V. Colocated	(18) 113 $\pm$ 50	6.91 $\pm$ 4.83		(12) 107 $\pm$ 35	7.52 $\pm$ 5.08	
<b>2nd Quarter</b>						
F	(13) 20.1 $\pm$ 37.6	.60 $\pm$ 1.20	.069 $\pm$ .129	(9) 25.9 $\pm$ 44.4	.72 $\pm$ 1.43	.087 $\pm$ .153
C	(13) 7.5 $\pm$ 5.82	.12 $\pm$ .12	.006 $\pm$ .012	(9) 8.89 $\pm$ 6.47	.14 $\pm$ .12	.009 $\pm$ .013
L.V.	(11) 62.8 $\pm$ 46.5	2.46 $\pm$ 3.35	.22 $\pm$ .33	(9) 65.6 $\pm$ 53.6	2.11 $\pm$ 3.58	.19 $\pm$ .36
H.V.	(14) 83 $\pm$ 54	2.89 $\pm$ 3.47		(9) 86 $\pm$ 63	2.70 $\pm$ 4.26	
H.V. Colocated	(14) 91 $\pm$ 60	2.94 $\pm$ 3.39		(9) 91 $\pm$ 68	2.71 $\pm$ 4.16	
<b>3rd Quarter</b>						
F						
C						
L.V.						
H.V.						
<b>4th Quarter</b>						
F						
C						
L.V.						
H.V.						

Numbers in parenthesis preceding values are number of samples. The number of samples on which Pb and Cd measurements were made are the same as samples on which mass was determined unless otherwise noted.

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Table 4

## MASS, Pb and Cd MEAN VALUES AT SITE 4 (Hadfield) BY QUARTER

	All Valid Samples Average $\pm$ S.D. ( $\mu\text{g}/\text{m}^3$ )			Co-Collected Samples Average $\pm$ S.D. ( $\mu\text{g}/\text{m}^3$ )		
	Mass	Pb	Cd	Mass	Pb	Cd
1st Quarter						
F						
C						
L.V.						
H.V.						
2nd Quarter						
F						
C						
L.V.						
H.V.						
3rd Quarter						
F	(8) 11.2 $\pm$ 3.2	.82 $\pm$ .66	.125 $\pm$ .115	(7) 10.6 $\pm$ 2.8	.72 $\pm$ .64	.12 $\pm$ .12
C	(8) 14.4 $\pm$ 11.3	.43 $\pm$ .30	.014 $\pm$ .017	(7) 13.1 $\pm$ 11.6	.36 $\pm$ .23	.013 $\pm$ .019
L.V.	(11) 54.9 $\pm$ 27.1	1.96 $\pm$ 1.38	.18 $\pm$ .14	(7) 43.6 $\pm$ 18.8	1.43 $\pm$ .76	.13 $\pm$ .07
H.V.	(15) 117 $\pm$ 55	4.99 $\pm$ 2.68		(7) 84 $\pm$ 33	3.28 $\pm$ 1.87	
H.V. Colocated	(15) 118 $\pm$ 54	5.06 $\pm$ 2.76		(7) 82 $\pm$ 35	3.26 $\pm$ 1.90	
4th Quarter						
F	(30) 14.9 $\pm$ 9.7	.43 $\pm$ .33	.090 $\pm$ .097	(28) 15.5 $\pm$ 9.8	.45 $\pm$ .33	.095 $\pm$ .099
C	(30) 13.7 $\pm$ 10.2	.40 $\pm$ .36	.032 $\pm$ .040	(28) 14.2 $\pm$ 10.4	.42 $\pm$ .36	.033 $\pm$ .041
L.V.	(30) 49.2 $\pm$ 23.5	1.51 $\pm$ 1.08	.18 $\pm$ .21	(28) 50.5 $\pm$ 23.7	1.56 $\pm$ 1.10	.18 $\pm$ .21
H.V.	(28) 76 $\pm$ 32	2.27 $\pm$ 1.52	(25) 170 $\pm$ 185	(28) 76 $\pm$ 32	2.27 $\pm$ 1.52	(25) 170 $\pm$ 185
H.V. Colocated	(30) 77 $\pm$ 32	2.22 $\pm$ 1.49	(27) 180 $\pm$ 184	(28) 77 $\pm$ 32	2.22 $\pm$ 1.49	(27) 180 $\pm$ 184

Numbers in parenthesis preceding values are number of samples. The number of samples on which Pb and Cd measurements were made are the same as samples on which mass was determined unless otherwise noted.

Table 5

## MASS, Pb and Cd MEAN VALUES AT SITE 5 (Hastie) BY QUARTER

	All Valid Samples Average $\pm$ S.D. ( $\mu\text{g}/\text{m}^3$ )			Co-Collected Samples Average $\pm$ S.D. ( $\mu\text{g}/\text{m}^3$ )		
	Mass	Pb	Cd	Mass	Pb	Cd
1st Quarter						
F						
C						
L.V.						
H.V.	(20) 76 $\pm$ 38	3.19 $\pm$ 3.72				
2nd Quarter						
F						
C						
L.V.						
H.V.	(29) 77 $\pm$ 56	1.60 $\pm$ 1.47				
3rd Quarter						
F						
C						
L.V.						
H.V.	(25) 85 $\pm$ 37	2.34 $\pm$ 2.14				
4th Quarter						
F	(26) 19.2 $\pm$ 12.7	.67 $\pm$ .44	.14 $\pm$ .13	(23) 20.4 $\pm$ 13.0	.72 $\pm$ .44	.14 $\pm$ .14
C	(26) 16.9 $\pm$ 10.9	.66 $\pm$ .51	.051 $\pm$ .032	(23) 13.0 $\pm$ 11.1	.73 $\pm$ .51	.054 $\pm$ .032
L.V.	(27) 45.0 $\pm$ 19.8	1.72 $\pm$ 1.00	.20 $\pm$ .13	(23) 45.0 $\pm$ 21.2	1.82 $\pm$ 1.01	.21 $\pm$ .13
H.V.	(26) 69 $\pm$ 30	2.51 $\pm$ 1.52	(23) .191 $\pm$ .146	(23) 69 $\pm$ 29	2.56 $\pm$ 1.57	(21) .201 $\pm$ .149

Numbers in parenthesis preceding values are number of samples. The number of samples on which Pb and Cd measurements were made are the same as samples on which mass was determined unless otherwise noted.

Table 6

Cu, Zn and As--4th QUARTER MEAN CONCENTRATIONS ( $\mu\text{g}/\text{m}^3$ )

Site	Type	No.	All Valid Samples			Co-Collected Samples		
			Mean $\pm$ Std. Dev.			Mean $\pm$ Std. Dev.		
			Cu	Zn	As	Cu	Zn	As
Canal	H.V.	12 <sup>a</sup>	0.83 $\pm$ 0.60	0.73 $\pm$ 0.89	0.073 $\pm$ 0.067	-	-	-
Dartman	L.V.	29	1.31 $\pm$ 1.44	0.59 $\pm$ 0.47	0.154 $\pm$ 0.140	26	1.31 $\pm$ 1.44	0.59 $\pm$ 0.47
	H.V.	29	2.02 $\pm$ 2.39	0.82 $\pm$ 0.51	0.122 $\pm$ 0.100	26	2.20 $\pm$ 2.46	0.83 $\pm$ 0.54
Hadfield	F	30	0.175 $\pm$ 0.203	0.334 $\pm$ 0.296	0.107 $\pm$ 0.099	28	0.181 $\pm$ 0.212	0.335 $\pm$ 0.302
	C	30	0.552 $\pm$ 0.707	0.297 $\pm$ 0.323	0.045 $\pm$ 0.038	28	0.577 $\pm$ 0.725	0.302 $\pm$ 0.333
	L.V.	30	1.955 $\pm$ 2.054	1.067 $\pm$ 1.151	0.208 $\pm$ 0.158	28	2.021 $\pm$ 2.111	1.076 $\pm$ 1.191
	H.V.w	25 <sup>b</sup>	3.04 $\pm$ 3.52	1.01 $\pm$ 0.74	0.161 $\pm$ 0.123	25 <sup>b</sup>	3.04 $\pm$ 3.52	1.01 $\pm$ 0.74
	H.V.e	25 <sup>b</sup>	3.48 $\pm$ 4.06	1.14 $\pm$ 0.80	0.202 $\pm$ 0.124	25	3.48 $\pm$ 4.06	1.14 $\pm$ 0.80
Hiastie	F	26	0.255 $\pm$ .301	0.770 $\pm$ 0.479	0.237 $\pm$ 0.316	23	0.277 $\pm$ 0.316	0.838 $\pm$ 0.465
	C	26	0.757 $\pm$ .714	0.630 $\pm$ 0.428	0.082 $\pm$ 0.066	23	0.801 $\pm$ 0.748	0.686 $\pm$ 0.427
	L.V.	27	1.908 $\pm$ 1.595	1.573 $\pm$ 0.899	0.345 $\pm$ 0.229	23 <sup>b</sup>	1.926 $\pm$ 1.650	1.705 $\pm$ 0.868
	H.V.	23 <sup>b</sup>	3.58 $\pm$ 3.08	1.69 $\pm$ 1.07	0.272 $\pm$ 0.177	21	3.45 $\pm$ 3.13	1.78 $\pm$ 1.07
Highway	L.V.	23	13.38 $\pm$ 12.26	1.33 $\pm$ 0.79	0.341 $\pm$ 0.244	-	-	-
Microwave	H.V.	12 <sup>a</sup>	0.30 $\pm$ 0.16	0.18 $\pm$ 0.21	0.014 $\pm$ 0.015	-	-	-
Padbury	L.V.	27	0.031 $\pm$ 0.031	0.088 $\pm$ 0.083	0.024 $\pm$ 0.026	25	0.033 $\pm$ 0.035	0.093 $\pm$ 0.085
	H.V.	23 <sup>b</sup>	0.19 $\pm$ 0.07	0.20 $\pm$ 0.29	0.023 $\pm$ 0.020	22 <sup>b</sup>	0.12 $\pm$ 0.06	0.17 $\pm$ 0.27
South	F	29	0.044 $\pm$ 0.081	0.172 $\pm$ 0.194	0.080 $\pm$ 0.108	28	0.046 $\pm$ 0.0793	0.170 $\pm$ 0.201
	C	29	0.139 $\pm$ 0.301	0.143 $\pm$ 0.194	0.027 $\pm$ 0.043	28	0.143 $\pm$ 0.307	0.145 $\pm$ 0.201
	L.V.	28	0.291 $\pm$ 0.539	0.375 $\pm$ 0.455	0.113 $\pm$ 0.148	28 <sup>b</sup>	0.291 $\pm$ 0.539	0.375 $\pm$ 0.045
	H.V.	27 <sup>b</sup>	0.52 $\pm$ 0.70	0.54 $\pm$ 0.53	0.108 $\pm$ 0.113	25 <sup>b</sup>	0.54 $\pm$ 0.72	0.55 $\pm$ 0.55
Vollmer	H.V.	11 <sup>a</sup>	0.46 $\pm$ 0.32	0.58 $\pm$ 0.58	0.059 $\pm$ 0.062	-	-	-

a. The mean does not include 10/1 or 10/7 hi-vol samples collected.

b. The mean does not include 10/1, 10/4 or 10/7 hi-vol samples collected.

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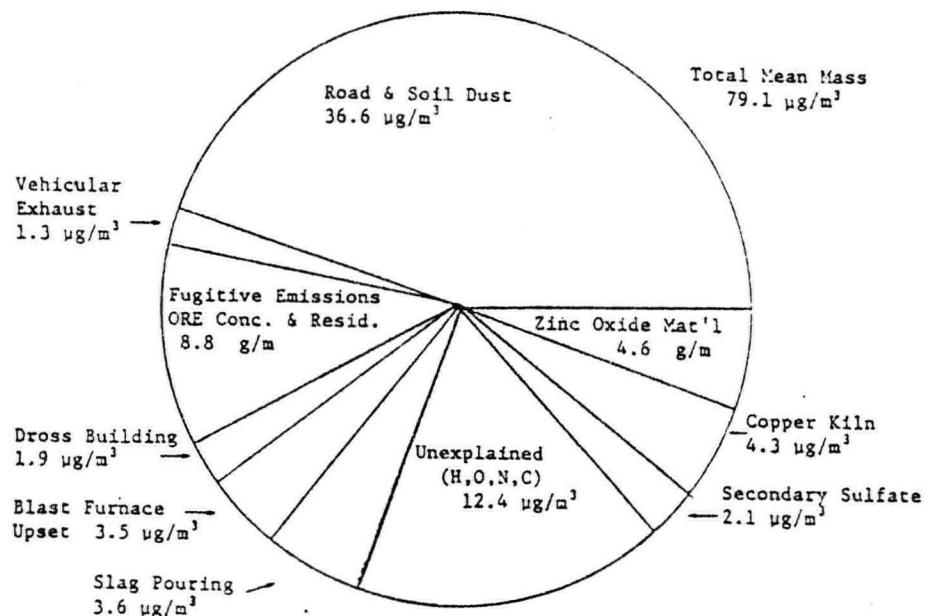
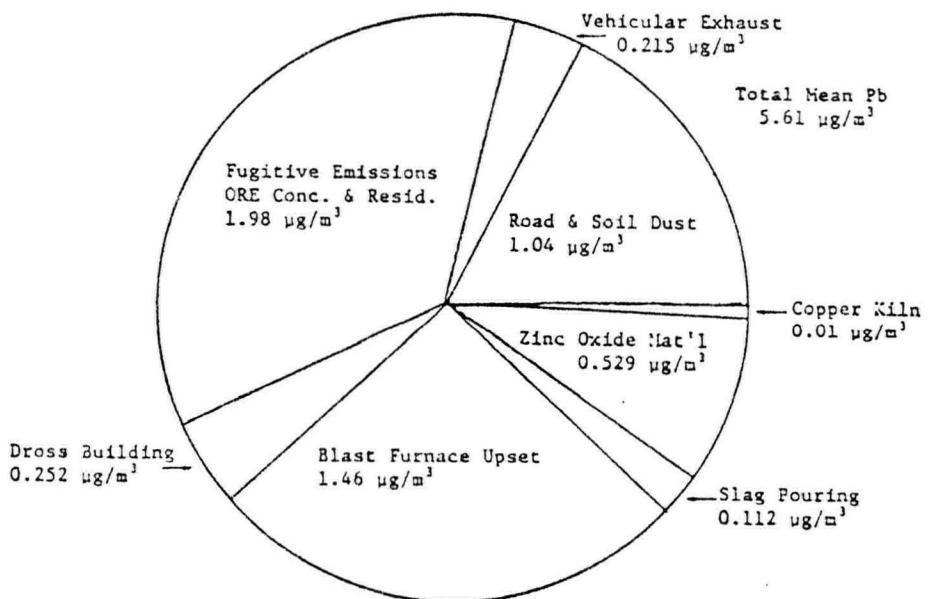
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Figure 24 CMB Source Apportionment - Firehall Site, First Quarter

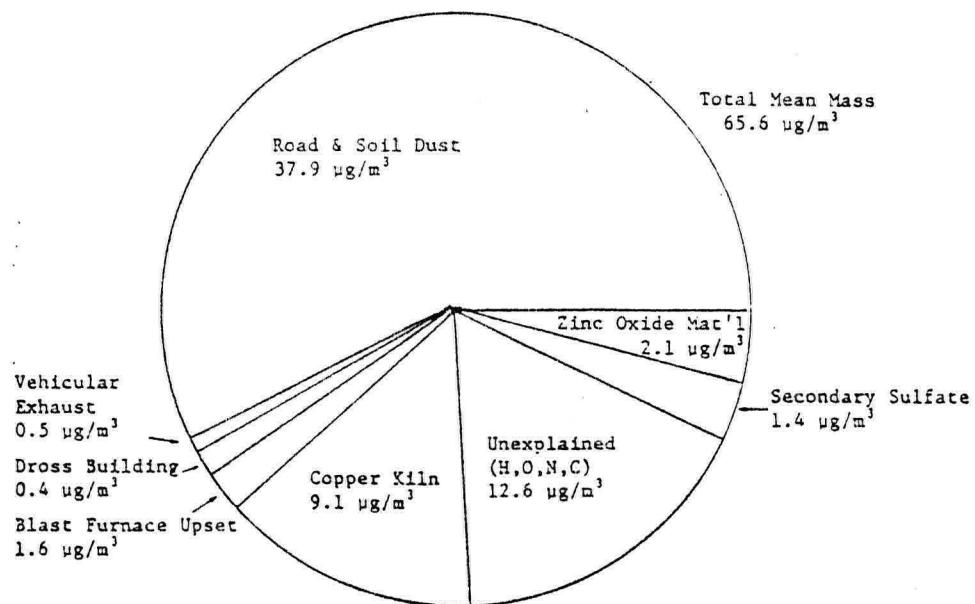
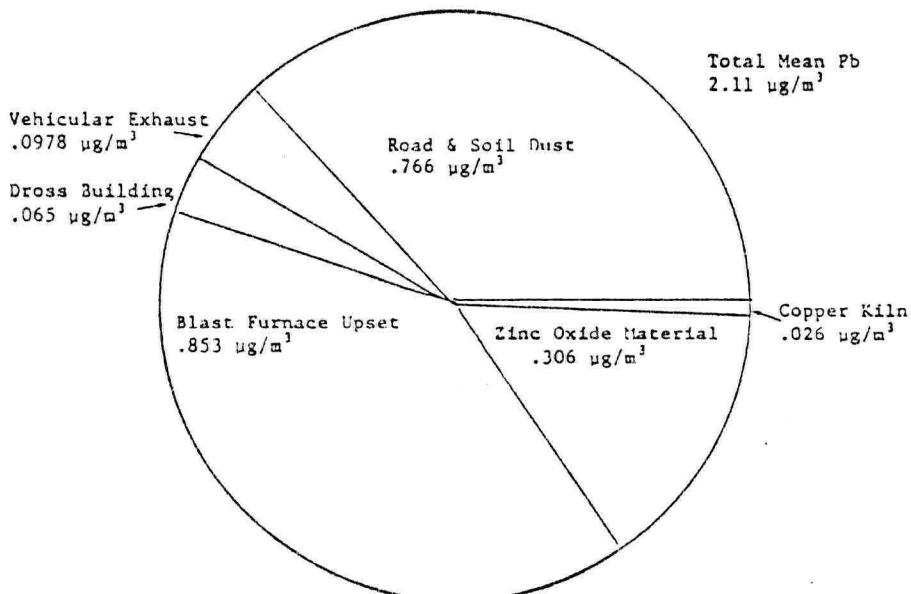
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Figure 25 CMB Source Apportionment - Firehall Site, Second Quarter

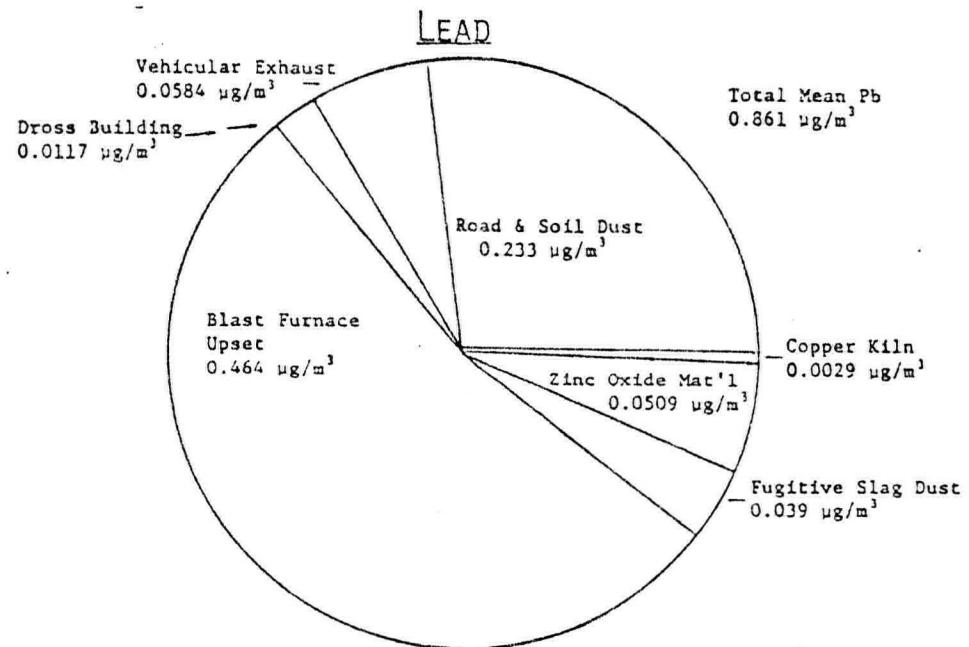
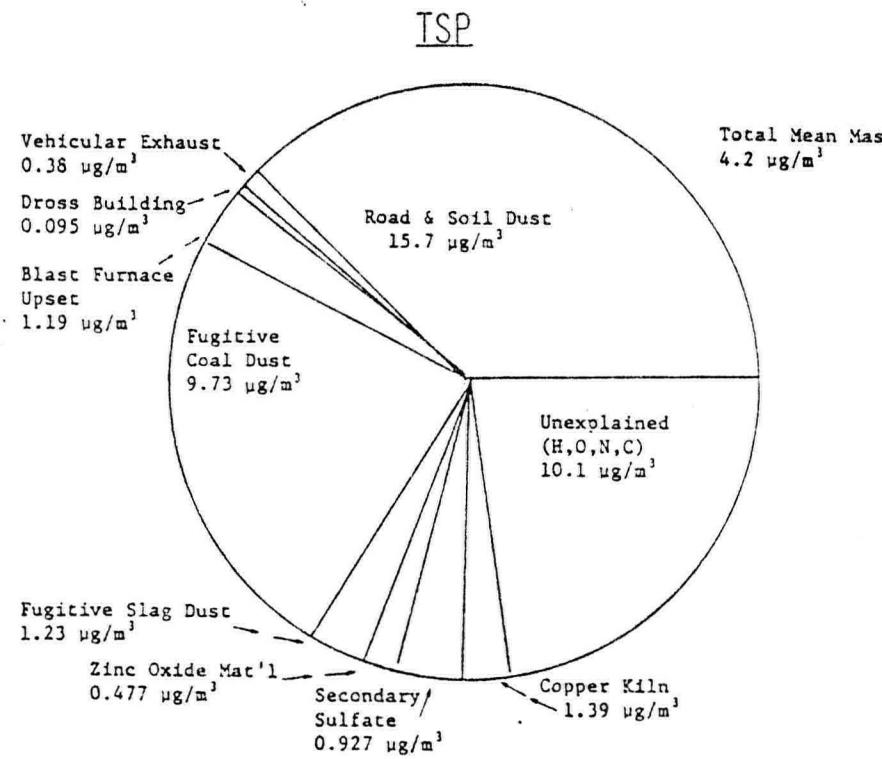


Figure 26 CMB Source Apportionment, Muffick Site, Second Quarter

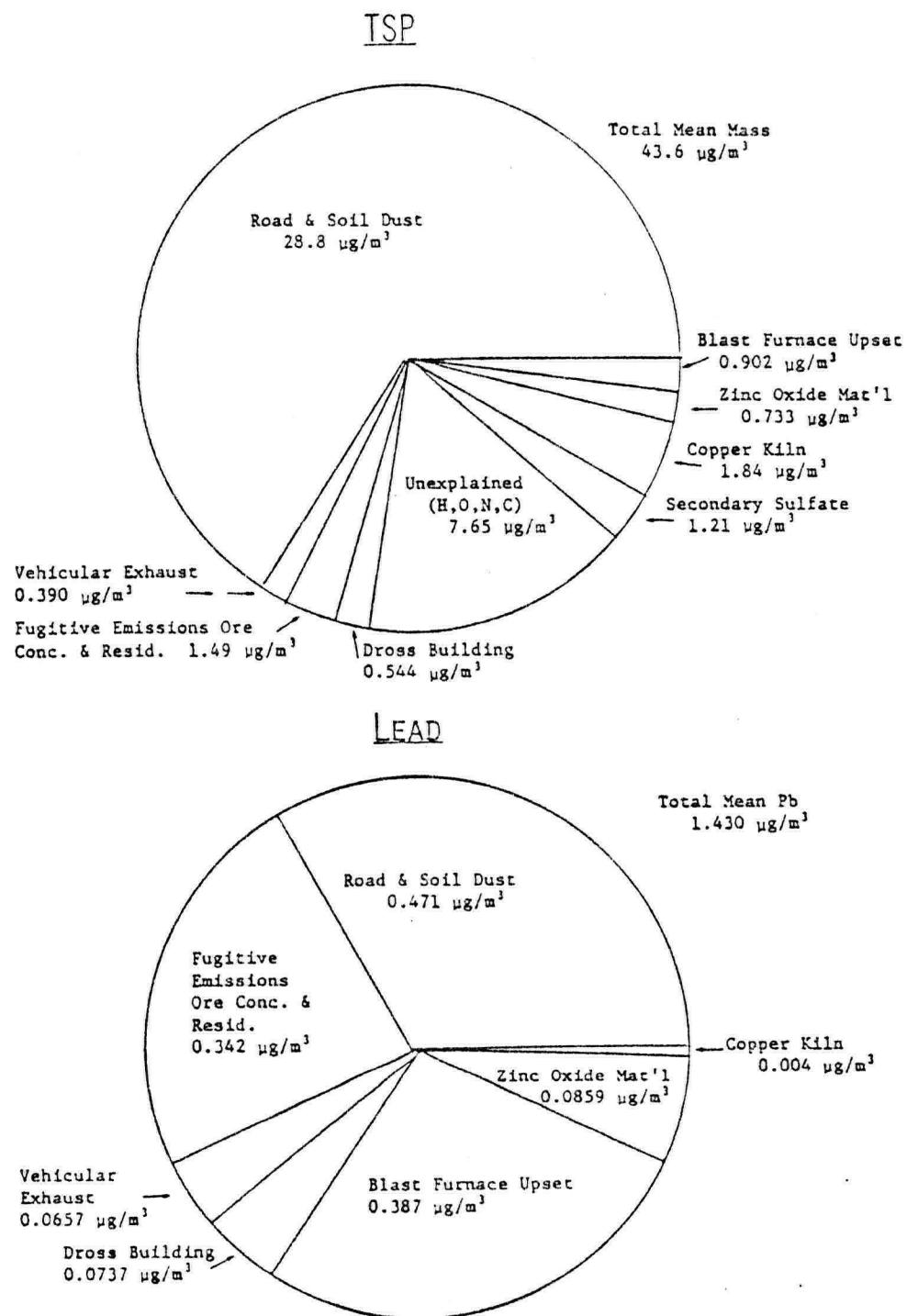


Figure 27 CMB Source Apportionment - Hadfield Site, Third Quarter

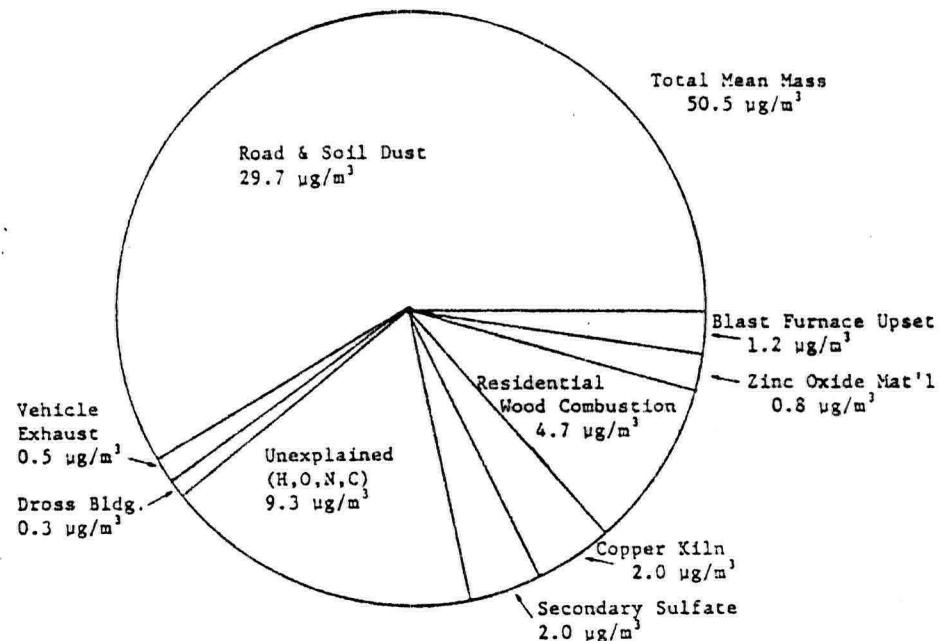
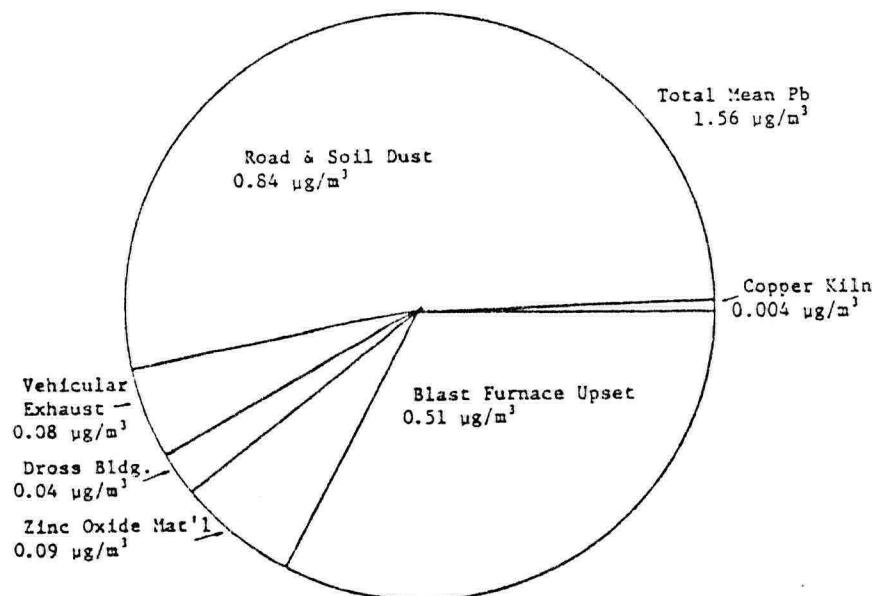
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Figure 28 CMB Source Apportionment - Hadfield Site, Fourth Quarter

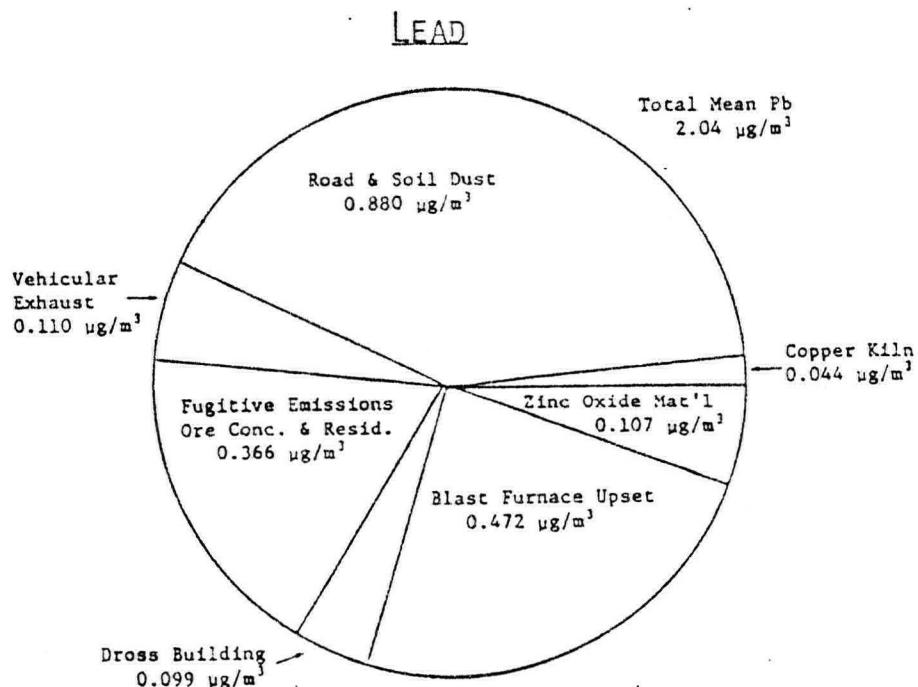
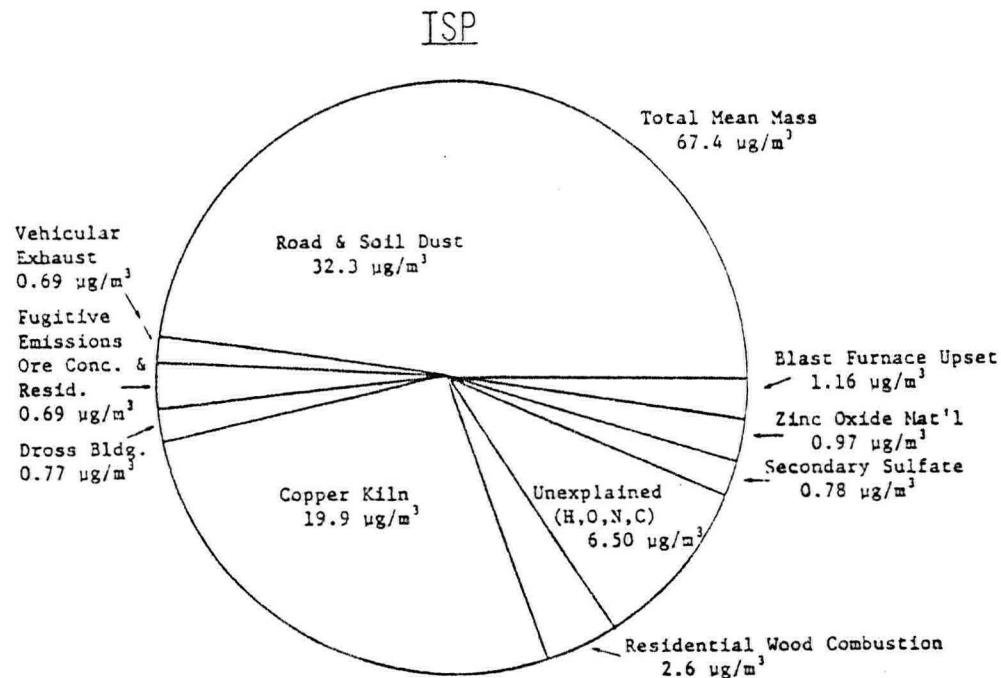


Figure 29 CMB Source Apportionment - Highway Site, Fourth Quarter

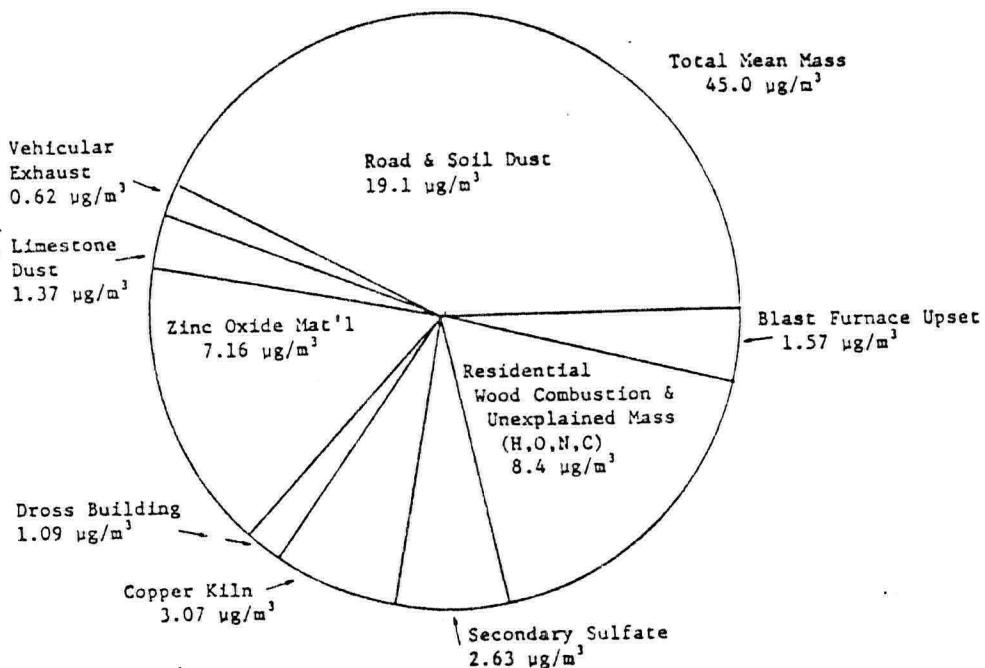
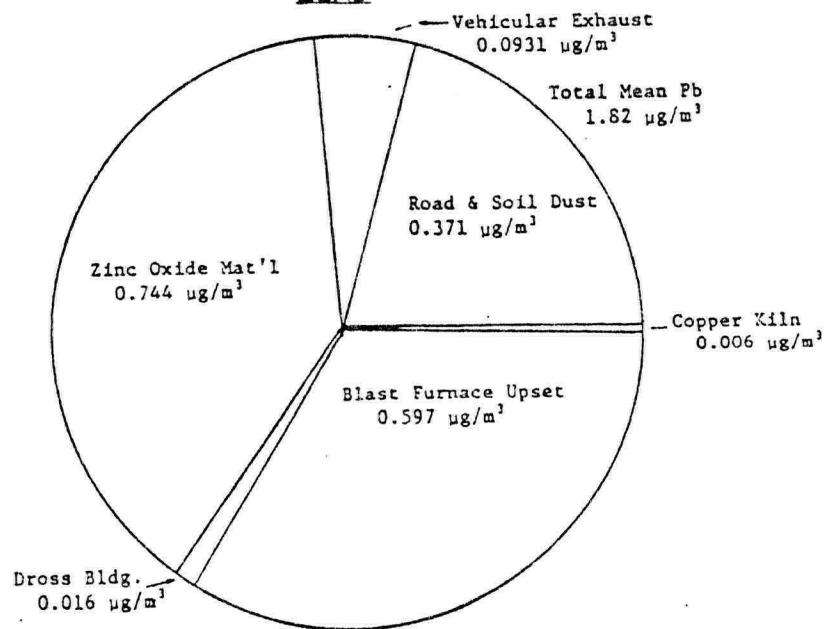
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Figure 30 CMB Source Apportionment - Hastie Site, Fourth Quarter

An ASARCO funded study<sup>1</sup> designed and carried out to determine what stack height was essential for a new baghouse stack to prevent sulfur dioxide fumigations in East Helena. These fumigations were caused by low level baghouse stack (120 foot) emissions prior to February of 1981. These same low-level emission studies appear to describe industrial particulate entry into East Helena under common drainage-flow (south wind) conditions, which occur most summer and fall mornings or inversion periods.

The study answered three questions:

1. Do downwash, wakes or eddy effects occur in the low level drainage flow due to influence of the smelter complex?
2. Are the downwash, wakes or eddy effects induced by the smelter resulting in excessive concentrations in the immediate vicinity of the source?
3. What stack height would be sufficient to avoid the effects of the smelter complex on the blast furnace baghouse plume under drainage flow conditions?

For question #1, under stable drainage flow meteorological conditions, sulfur hexafluoride was released at various heights (roughly 400 to 500 feet above ground level) over the smelter. Simultaneous releases were made under identical meteorological conditions east of the smelter but removed from smelter influence for control purposes. Field study results showed equivalent SO<sub>2</sub> impacts in excess of the national ambient air quality standards where those releases over the smelter gave concentrations which ranged from fifty to several hundred percent in excess of parallel releases away from smelter influence. These data confirm that the smelter causes excessive impacts in the immediate vicinity of the smelter grounds.

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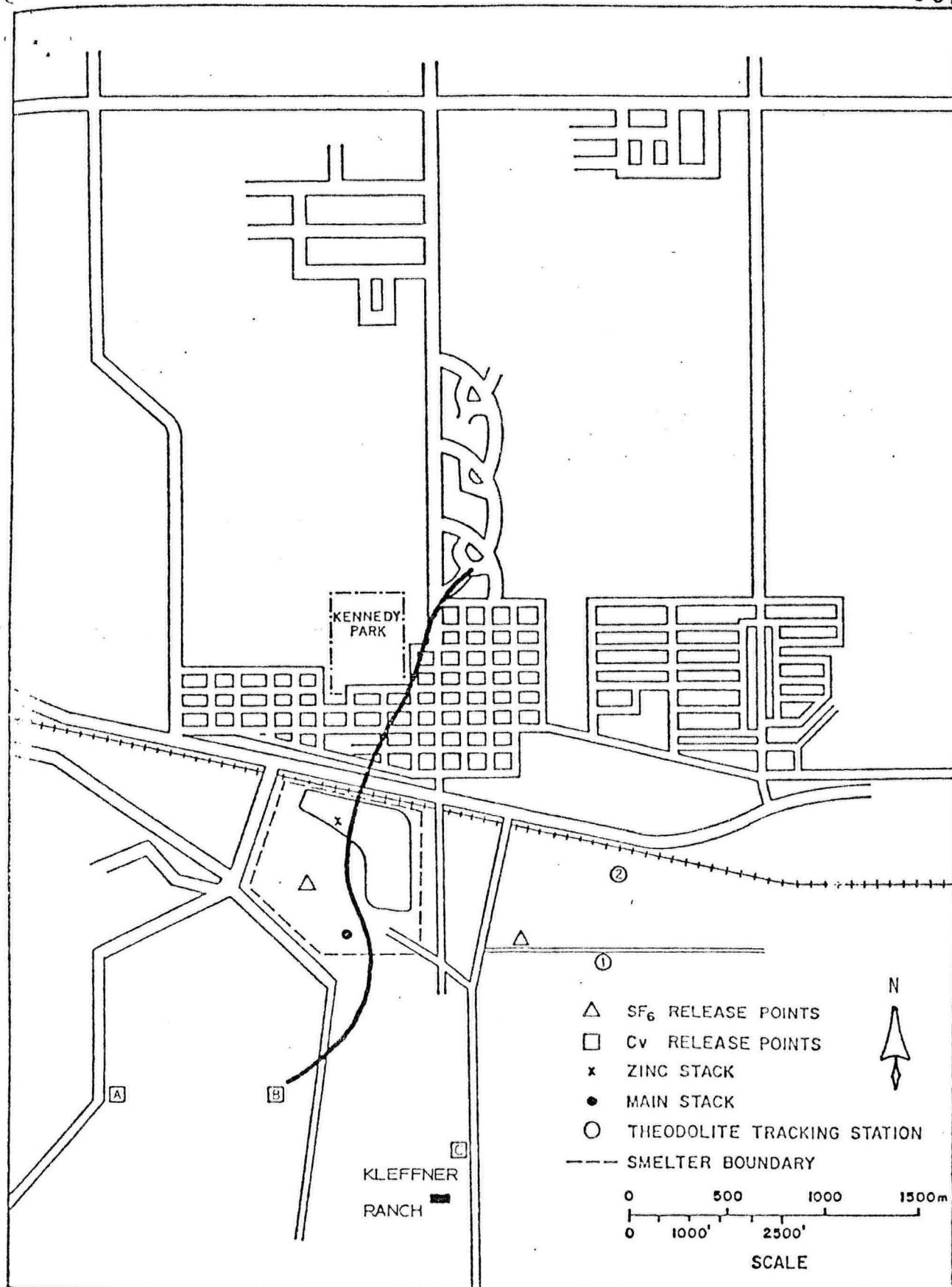
<sup>1</sup>"A Field Study to Determine Good Engineering Practice Stack Height for the ASARCO East Helena Smelter Blast Furnace Baghouse" by Allen J. Schanot, Timothy C. Spangler, Einar L. Hovind, Gordon R. MacRae of North American Weather Consultants, Salt Lake City, Utah, January, 1981.

Addressing question #2, constant volume (CV) balloons were simultaneously released upwind of the smelter such that one would pass over the smelter while the other would not be influenced by the smelter. Both were influenced by the same general air flow patterns. CV balloon data "mapped" the vertical and horizontal extent of the disturbance. Smoke releases from the 200 foot level of the main sinter plant stack provided a visual record of low-level smelter emissions as they move northward across the city under common drainage flow conditions.

Figures 31 and 32 show vertical and horizontal components of a balloon release. This balloon CV-4 was released at a height of 350 feet. It ascended slightly over the smelter but then dipped sharply on the leeward side of the slag pile to within about 115 feet of the city of East Helena before it was lost from sight. Figures 33 and 34 show CV-5, the simultaneously CV balloon release to CV-4, but away from smelter influence. This balloon, initially released at 375 feet, showed marked ascent downwind of the zinc stack as expected under stable drainage flow conditions.

Simultaneous over-the-smelter and parallel balloon releases are shown in Figure 35. Smelter releases take strong downward dips over the city but generally ascended again unless lost from view. Balloons which descended too low were burst upon collision with powerlines, buildings, etc. The hybrid trajectory, though released upwind of the smelter, skirted just east of the smelter complex. It was also influenced by the slag pile downwash air currents.

Figures 36 and 37 show nighttime white smoke releases from the main sinter plant stack. Figure 36 shows smoke proceeding northward, while Figure 37 shows the trough created by the smoke plume over the city of East Helena. These copies of nighttime color prints clearly show the bottom of the smoke plume was



Horizontal trajectory of the CV-4 launched during Release Case #2 at 0240 MDT on September 27, 1980.

Figure 31

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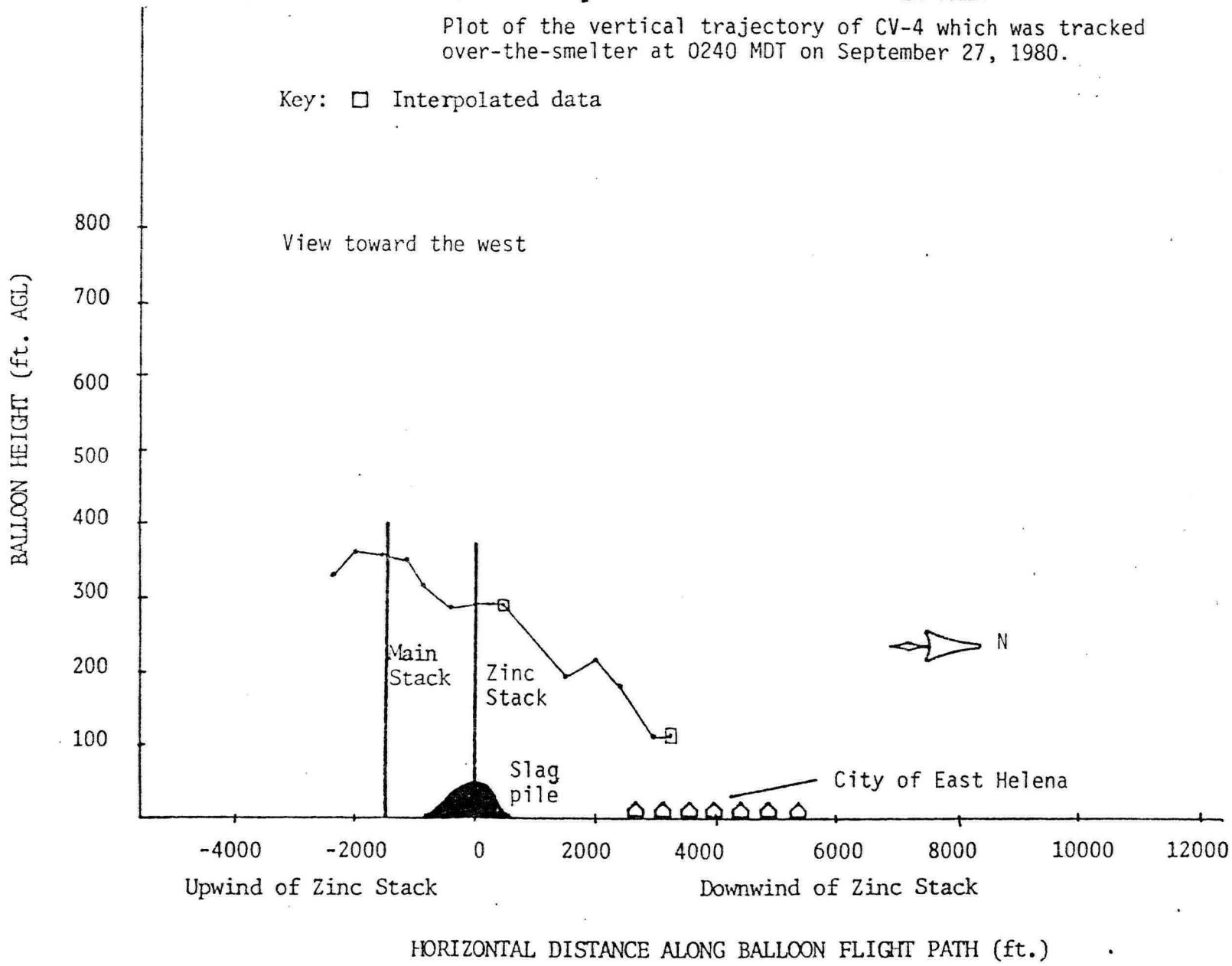
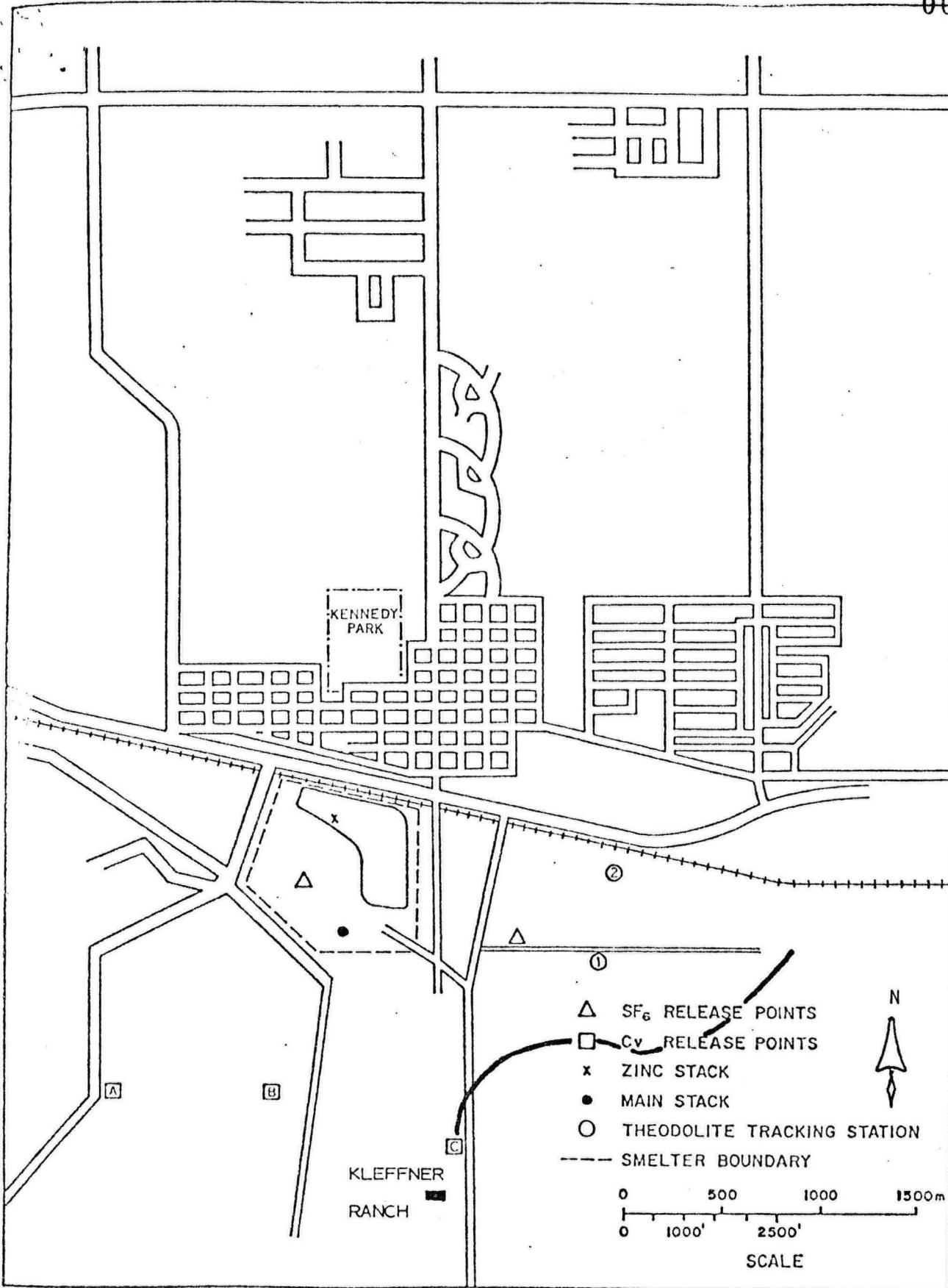


Figure 32



Horizontal trajectory of CV-5 launched during Release Case #2  
at 0423 MDT on September 27, 1980.

Figure 33

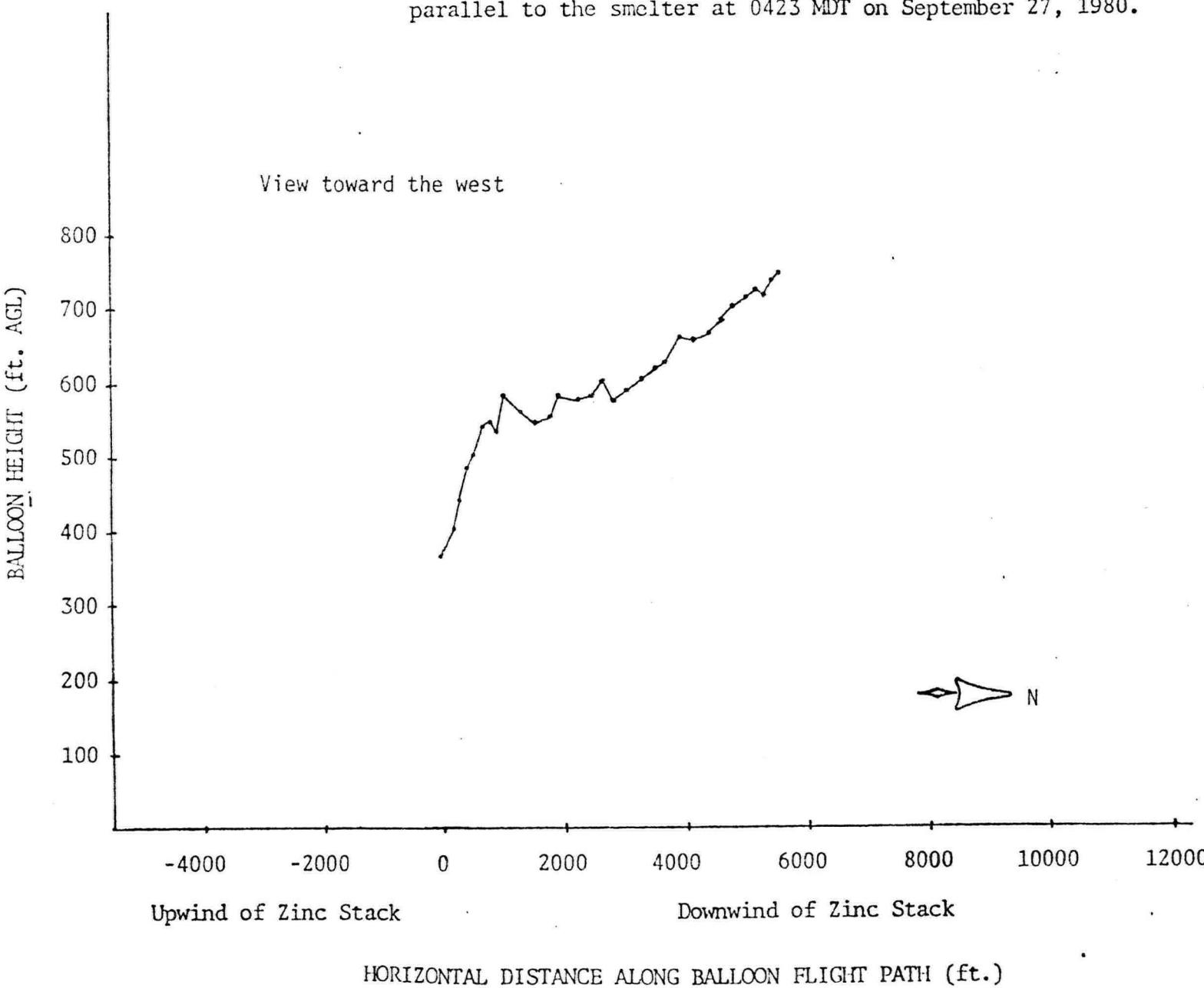
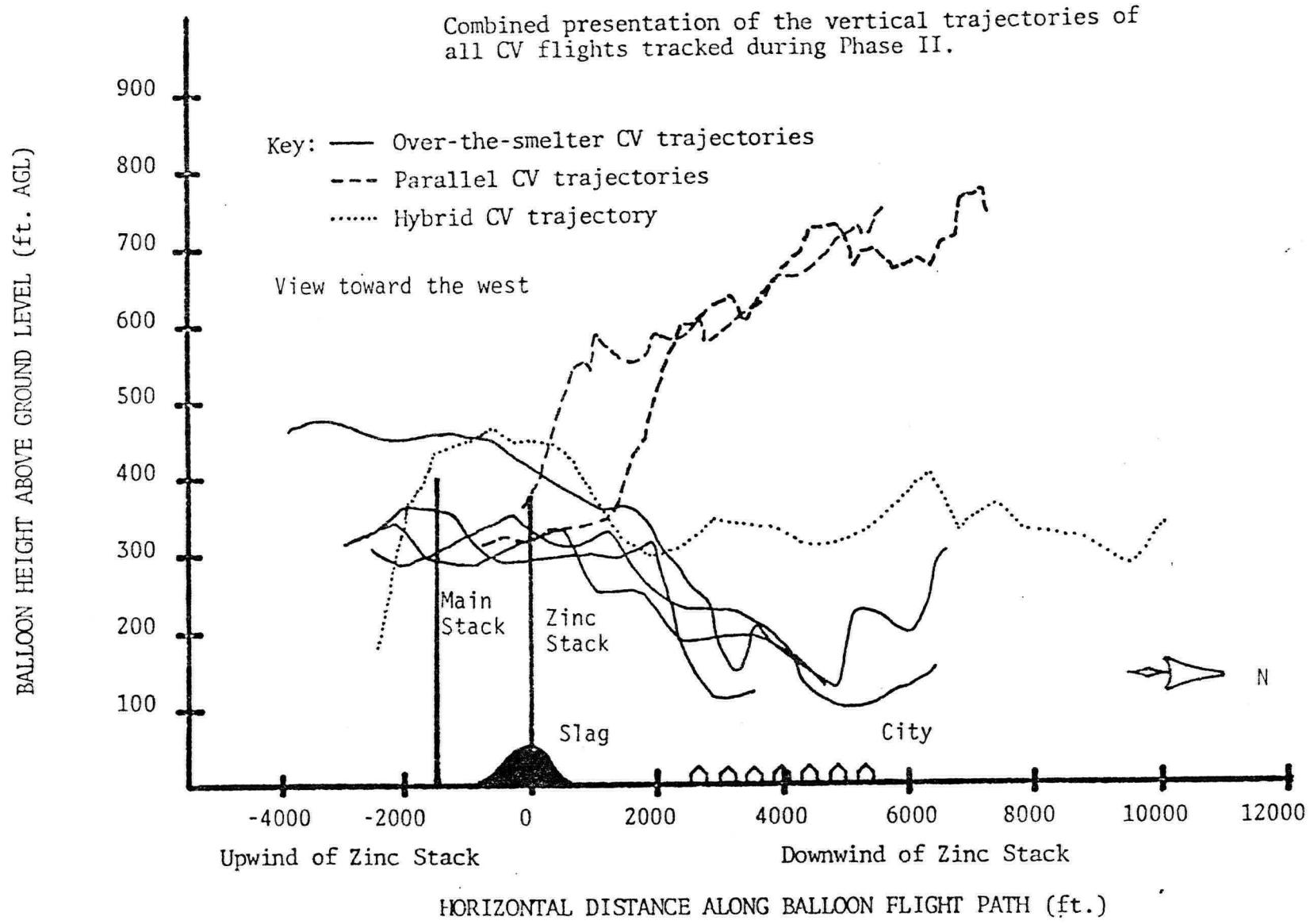
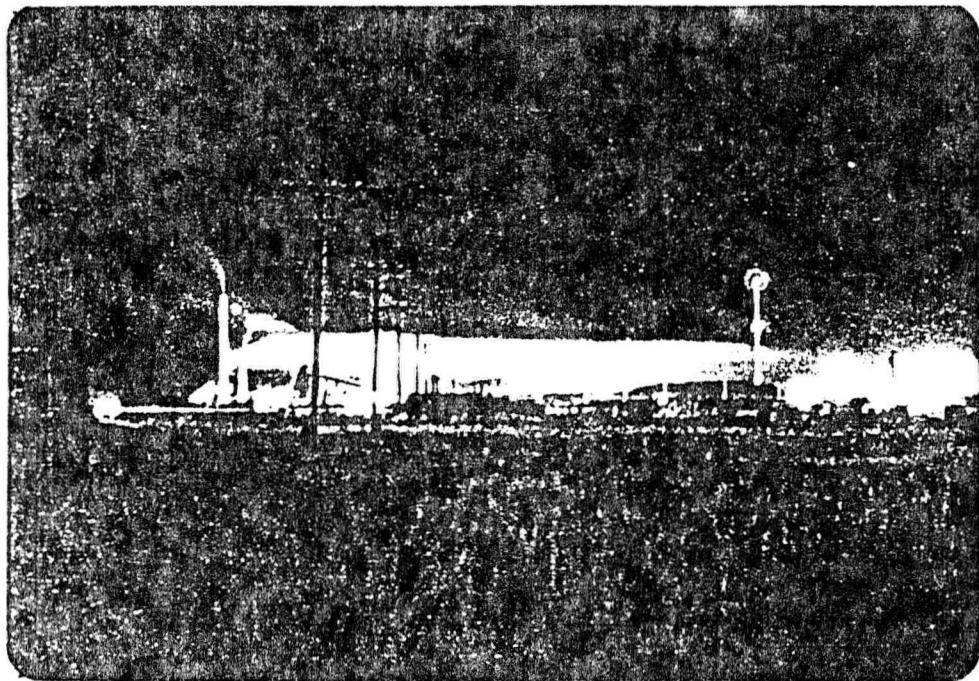


Figure 24

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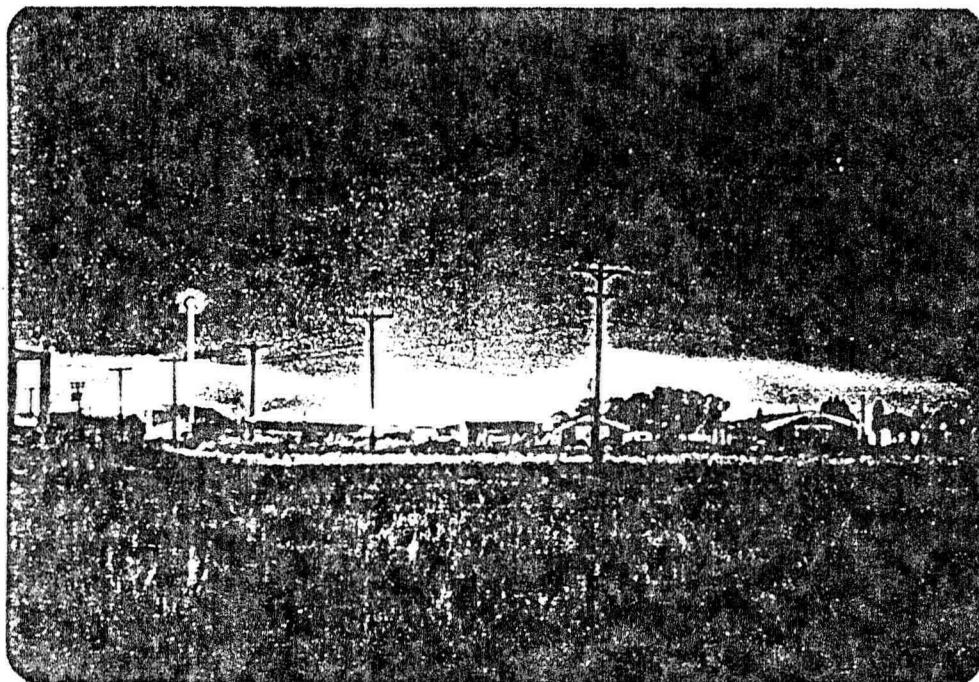
Figure 35  
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Initial photograph of the smoke plume released from the 175 ft level of the main stack. This photo is a 10 second time exposure taken at approximately 0352 MDT on September 27, 1980 during Release Case #3. The leading edge of the smoke plume has just reached the zinc stack. The picture shows the flow across the smelter to be relatively undisturbed.

Figure 36



This photo is a 10 second time exposure taken at approximately 0255 MDT on September 27, 1980 during Release Case #3. The leading edge of the smoke plume has now passed to the north of the residential area of East Helena. The top of the smoke plume shows the flow in a wavelike pattern with a trough located on the leeward side of the slag pile. The distance between the bottom of the trough and the slag pile corresponds to the approximate distance from the slag pile to Kennedy Park.

Figure 37

diffuse and mixed slowly downward as it crossed the smelter. The downward thrust of the plume over the city itself is seen in Figure 37. The smoke plume maintained a sharp boundary on the top throughout its path across the smelter and East Helena during the smoke releases.

The above summarized data establish the smelter as the cause of the wavelike disturbance anchored by the slag pile. This disturbance will affect plume dispersion and smelter emissions up to at least 450 feet and is capable of bringing emissions from up to that height to the surface as they pass over East Helena.

For question #3, good engineering practice defined a stack height of 420 feet based on the above study.

### Residential House Dust

Dust was carefully removed by camel hair brush from outside window sills from residences shown in Figure 38 and in Table 7. Atomic absorption analyses give bulk lead, cadmium, arsenic, zinc, copper and iron concentrations shown. Residential lead, cadmium, arsenic, zinc and iron concentrations peak out in the areas of samples 3 and 4, but high copper concentrations are noted across from American Chemet, which produces copper oxide paint pigments.

In addition to the above sampling, samples of outside house dust were collected by vacuuming window sills, awnings, stucco siding and sidewalk surfaces to obtain a sample large enough to sieve. The less than 38 micron portion was resuspended into F (less than 2.5  $\mu$ ), C (2.5 to 15  $\mu$ ), and T (0 to 30  $\mu$ ) size fractions. These samples were analyzed for 28 elements by x-ray fluorescent analysis and are shown in Figures 39, 39a and 40, which present data for respirable, inhalable and suspended particulates.

Similar data is also presented for resuspended vacuum cleaner dust which is assumed to represent inside house dust (see Figures 41 to 43).

Figure 44 shows actual particulate concentrations for the four-lane highway just north of the American Chemet plant shown in Figure 38.

Chemical-mass-balance calculations, as explained earlier in the Source Identification section, are also included for each of these samples. Sources identified here should be considered only qualitatively.

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Window sill dust sampling locations in East Helena, Montana.  
Shown are the American CHEMET and ASARCO industrial complexes.

TABLE 7  
 Window Sill Dust  
 collected on 10/9/79 in East Helena, MT  
 Chemical Composition  
 DM

	Location	Lead	Cadmium	Arsenic	Zinc	Copper	Iron
1.	212 E. Pacific Ave.	57,910	347	2,400	15,100	93,500	41,170
2.	126 E. Pacific Ave.	63,680	537	2,500	19,900	102,300	41,170
3.	102 E. Pacific Ave.	101,333	667	4,060	32,300	223,667	40,467
4.	20 E. Pacific Ave.	93,800	849	3,400	26,600	194,700	43,510
5.	2 E. Pacific Ave.	33,840	657	900	13,100	97,800	30,360
6.	10 W. Pacific Ave.	49,190	651	1,500	13,600	574,200	24,350
7.	8 W. Pacific Ave.	52,990	579	1,800	14,300	443,400	27,400
8.	110 W. Pacific Ave.	50,850	764	1,800	17,600	234,800	31,620
9.	Vacuum Cleaner Dust (10 W. Pacific)	6,600	113	200	2,760	19,770	9,760
10.	Dust from ASARCo Air Monitoring Site	128,300	1,220	3,600	34,500	91,300	55,520

All Values = ppm (Parts per Million)

Montana Department of Health and  
Environmental Sciences

10,000 ppm = 1%  
100,000 ppm = 10%

Analysis completed by Montana Dept of Health  
using AA.

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## SUSPENDED RESULTS FOR CMB # RS408

## FINE PARTICULATE FRACTION

SAMPLING DATE: 019999 SITE CODE: 09

SAMPLING DURATION: 99 HRS. WITH START HOUR: 99

SITE: House #6

EFFECTIVE VARIANCE FITTING. REDUCED CHI-SQUARE: 1.008 D OF F: 10  
CODE SOURCE FLG UG/M3 %

14	GEO-K	*	99.737+-6.389	99.737+-11.850
74	ZHKLD	*	4.006+-1.678	4.006+-1.725
75	CUKST	*	2.270+-0.709	2.270+-0.745
79	ORCOM	*	2.498+-2.255	2.498+-2.269
<hr/>				
TOTAL:		108.512+-7.025	108.512+-12.927	

SPECIE FINE SUSPENDED PARTICULATE  
CODE MEAS. UG/M3 PERCENT CALC. UG/M3 RATIO

1	AL	*	8.384+-0.838	8.384	8.498+-0.840	1.014+-0.143	AL
2	SI	*	23.734+-2.373	23.734	24.728+-2.451	1.042+-0.149	SI
3	P		0.401+-0.040	0.401	0.325+-0.037	0.811+-0.119	P
4	S	*	3.927+-0.393	3.927	3.663+-0.354	0.933+-0.123	S
5	CL		0.245+-0.049	0.245	0.255+-0.052	1.041+-0.307	CL
6	K	*	1.420+-0.142	1.420	1.376+-0.133	0.969+-0.130	K
7	CA	*	5.135+-0.513	5.135	5.085+-0.502	0.990+-0.137	CA
8	TI	*	0.449+-0.045	0.449	0.320+-0.032	0.736+-0.080	TI
9	V		0.023+-0.005	0.023	0.026+-0.006	1.152+-0.294	V
10	CR		0.054+-0.006	0.054	0.024+-0.007	0.444+-0.142	CR
11	MN	*	0.138+-0.014	0.138	0.161+-0.019	1.166+-0.216	MN
12	FE	*	4.859+-0.486	4.859	4.497+-0.450	0.925+-0.126	FE
13	NI		0.064+-0.008	0.064	0.052+-0.009	0.813+-0.183	NI
14	CU	*	2.811+-0.281	2.811	2.617+-0.230	1.002+-0.116	CU
15	ZN	*	8.113+-0.811	8.113	8.117+-0.609	1.000+-0.106	ZN
16	AS	*	0.755+-0.075	0.755	0.746+-0.100	0.988+-0.187	AS
17	SE		0.021+-0.005	0.021	0.035+-0.006	1.664+-0.573	SE
18	BR	*	0.093+-0.009	0.093	0.113+-0.013	1.277+-0.233	BR
19	SR		0.050+-0.007	0.050	0.039+-0.009	0.773+-0.237	SR
20	PD	<	0.018	---	0.036+-0.025	2.025+-3.407	PD
21	AG		0.053+-0.026	0.053	0.037+-0.040	0.705+-0.935	AG
22	DD	*	0.333+-0.053	0.333	0.425+-0.073	1.278+-0.355	DD
23	IN	<	0.044	---	0.002+-0.063	0.065+-1.968	IN
24	SN		0.210+-0.054	0.210	0.093+-0.071	0.444+-0.371	SN
25	SB		0.340+-0.103	0.340	0.192+-0.166	0.566+-0.561	SB
26	BA	<	0.224	---	0.643+-0.344	0.000+-0.000	BA
27	HG		0.015+-0.009	0.015	0.039+-0.013	2.617+-2.424	HG
28	PE	*	5.782+-0.578	5.782	5.301+-0.567	0.922+-0.133	PE

MEAS. AMB. MASS (UG/M3): 100.0

\* - FITTING ELEMENT

Chemical-mass-balance Analyses of  
Outside House Dust--Fine Fraction

## CM8DEC RESULTS FOR CMB # R8409

## COARSE PARTICULATE FRACTION

SAMPLING DATE: 818999 SITE CODE: 09

SAMPLING DURATION: 99 HRS. WITH START HOUR: 99

SITE: House #6

EFFECTIVE VARIANCE FITTING. REDUCED CHI-SQUARE: 0.697 D.F. F: 9  
CODE SOURCE FLAG UG/M3 %

1	TRANS	*	0.113+-	0.091	0.113+-	0.092
14	GEO-K	*	74.694+-	4.144	74.694+-	8.542
63	DLBLD	*	2.551+-	0.722	2.551+-	0.766
74	ZHKLD	*	1.700+-	0.509	1.700+-	0.537
75	CUKST	*	7.717+-	1.599	7.717+-	1.775
<b>TOTAL:</b>			<b>86.775+-</b>	<b>4.530</b>	<b>86.775+-</b>	<b>9.789</b>

SPECIE CODE	COARSE SUSPENDED PARTICULATE			RATIO
	MEAS.	UG/M3	PERCENT	
1 AL *	5.259+-	0.526	5.259	4.989+- 0.494 0.948+- 0.129 AL
2 SI *	17.171+-	1.717	17.171	17.289+- 1.718 1.007+- 0.142 SI
3 P	0.239+-	0.024	0.239	0.182+- 0.016 0.761+- 0.082 P
4 S *	1.977+-	0.210	1.977	1.890+- 0.147 0.956+- 0.103 S
5 CL	0.081+-	0.028	0.081	0.229+- 0.023 2.823+- 0.849 CL
6 K *	1.042+-	0.104	1.042	1.145+- 0.111 1.099+- 0.159 K
7 CA *	3.646+-	0.365	3.646	4.019+- 0.391 1.102+- 0.159 CA
8 TI *	0.289+-	0.029	0.289	0.277+- 0.027 0.959+- 0.131 TI
9 V	0.021+-	0.004	0.021	0.017+- 0.002 0.794+- 0.136 V
10 CR	0.033+-	0.004	0.033	0.020+- 0.002 0.615+- 0.080 CR
11 MN *	0.118+-	0.012	0.118	0.123+- 0.012 1.044+- 0.144 MN
12 FE *	3.716+-	0.372	3.716	3.480+- 0.335 0.937+- 0.124 FE
13 HI	0.056+-	0.006	0.056	0.044+- 0.003 0.791+- 0.067 HI
14 CU *	7.089+-	0.709	7.089	7.105+- 0.508 1.662+- 0.101 CU
15 ZN *	2.543+-	0.254	2.543	2.609+- 0.178 1.026+- 0.100 ZN
16 AS *	0.414+-	0.041	0.414	0.400+- 0.028 0.967+- 0.094 AS
17 SE	0.003+-	0.003	0.002	0.013+- 0.002 4.499+- 2.530 SE
18 BR *	0.040+-	0.004	0.040	0.040+- 0.004 1.007+- 0.149 BR
19 SR	0.047+-	0.005	0.047	0.035+- 0.003 0.739+- 0.078 SR
20 PD	<	0.011	---	0.028+- 0.005 3.059+- 1.753 PD
21 AG	0.042+-	0.016	0.042	0.033+- 0.008 0.779+- 0.250 AG
22 CD *	0.143+-	0.029	0.143	0.191+- 0.016 1.334+- 0.187 CD
23 IN	<	0.027	---	0.001+- 0.012 0.000+- 0.000 IN
24 SN	0.064+-	0.031	0.064	0.072+- 0.014 1.130+- 0.339 SN
25 SB	0.135+-	0.061	0.135	0.171+- 0.029 1.266+- 0.344 SB
26 BA	<	0.143	---	0.008+- 0.062 0.000+- 0.000 BA
27 HG	0.011+-	0.006	0.011	0.010+- 0.003 0.914+- 0.375 HG
28 PB *	3.945+-	0.394	3.945	3.223+- 0.239 0.817+- 0.078 PB

AS. AMB. MASS (UG/M3): 100.0

\* - FITTING ELEMENT

Chemical-mass-balance Analyses of  
Outside House Dust--Course Fraction

## CMBDEQ RESULTS FOR CMB # RL023

## TOTAL PARTICULATE FRACTION

SAMPLING DATE: 819999 SITE CODE: 09

SAMPLING DURATION: 99 HRS. WITH START HOUR: 99

SITE: House #6

EFFECTIVE VARIANCE FITTING. REDUCED CHI SQUARE: 0.306 D OF F: 9  
CODE SOURCE FLG UG/M3 %

14	GEO-K	*	77.166+-	5.233	77.166+-	9.323
32	CUKLN	*	14.443+-	2.927	14.443+-	3.264
64	HDBLD	*	4.826+-	2.438	4.826+-	2.485
65	ZHBLD	*	1.856+-	1.699	1.856+-	1.709
79	ORCOM	*	2.767+-	1.977	2.767+-	1.997

TOTAL: 101.058+- 6.978 101.058+-12.281

SPECIE CODE	MEAS.	TOTAL UG/M3	SUSPENDED PARTICULATE		RATIO
			PERCENT	CALC. UG/M3	
1 AL *	4.217+-	0.422	4.217	4.344+-	0.425 1.030+-0.145 AL
2 SI *	15.713+-	1.571	15.713	15.510+-	1.520 0.987+-0.136 SI
3 P	0.169+-	0.017	0.169	0.161+-	0.013 0.953+-0.105 P
4 S *	1.451+-	0.196	1.451	1.503+-	0.164 1.036+-0.163 S
5 CL	< 0.017	---	---	0.018+-	0.011 0.000+-0.000 CL
6 K *	0.822+-	0.082	0.822	0.966+-	0.091 1.175+-0.170 K
7 CA *	3.733+-	0.373	3.733	3.542+-	0.331 0.949+-0.122 CA
8 TI *	0.277+-	0.028	0.277	0.250+-	0.023 0.904+-0.113 TI
9 V	0.024+-	0.002	0.024	0.020+-	0.002 0.822+-0.089 V
10 CR	0.029+-	0.003	0.029	0.034+-	0.002 1.157+-0.123 CR
11 MN *	0.131+-	0.013	0.131	0.131+-	0.014 0.997+-0.146 MN
12 FE *	4.141+-	0.414	4.141	3.819+-	0.355 0.922+-0.117 FE
13 HI	0.103+-	0.010	0.103	0.090+-	0.006 0.874+-0.080 HI
14 CU *	17.612+-	1.761	17.612	17.707+-	1.284 1.005+-0.103 CU
15 ZH *	2.138+-	0.214	2.138	2.090+-	0.168 0.978+-0.110 ZH
16 AS *	0.345+-	0.034	0.345	0.372+-	0.106 1.078+-0.454 AS
17 SE	0.012+-	0.002	0.012	0.008+-	0.001 0.692+-0.091 SE
18 BR *	0.044+-	0.004	0.044	0.042+-	0.009 0.948+-0.277 BR
19 SR	0.048+-	0.005	0.048	0.042+-	0.005 0.875+-0.149 SR
20 PD	0.011+-	0.004	0.011	0.018+-	0.004 1.660+-0.635 PD
21 AG	0.036+-	0.006	0.036	0.050+-	0.018 1.401+-0.878 AG
22 CD *	0.143+-	0.014	0.143	0.149+-	0.011 1.039+-0.115 CD
23 IN	0.029+-	0.008	0.029	0.014+-	0.006 0.486+-0.211 IN
24 SN	0.131+-	0.014	0.131	0.084+-	0.011 0.638+-0.095 SN
25 SB	0.279+-	0.028	0.279	0.319+-	0.155 1.142+-0.844 SB
26 BA	< 0.045	---	---	0.090+-	0.032 6.456+-14.8 BA
27 HG	0.010+-	0.003	0.010	0.011+-	0.002 1.062+-0.286 HG
28 PB *	4.370+-	0.437	4.370	4.314+-	0.525 0.987+-0.169 PB

AS. AMB. MASS (UG/M3): 100.0

\* - FITTING ELEMENT

## CHBDEQ RESULTS FOR CMB # RS410

## FINE PARTICULATE FRACTION

SAMPLING DATE: 8109309 SITE CODE: 09

SAMPLING DURATION: 99 HRS. WITH START HOUR: 99

SITE: House #6

EFFECTIVE VARIANCE FITTING. REDUCED CHI-SQUARE: 0.625 D OF F: 9  
CODE SOURCE FLG UG/M3 %

14	GEO-K	*	68.387+-23.268	68.387+-24.252
15	GEO-L	*	9.068+-25.147	12.582+-25.163
75	CUKST	*	1.145+-1.072	1.145+-1.072
	TOTAL:		78.600+-34.277	78.600+-35.166

SPECIE CODE	MEAS.	FINE UG/M3	SUSPENDED PERCENT	PARTICULATE CALC. UG/M3	RATIO	
1 AL *	7.637+-2.520	7.637	6.663+-0.581	0.872+-0.101	AL	
2 SI *	17.658+-5.780	17.658	19.457+-1.698	1.192+-0.143	SI	
3 P	0.439+-0.180	0.439	0.236+-0.026	0.537+-0.066	P	
4 S *	3.215+-1.144	3.215	2.289+-0.231	0.712+-0.088	S	
5 CL	0.522+-0.228	0.522	0.172+-0.036	0.330+-0.072	CL	
6 K *	1.089+-0.371	1.089	1.082+-0.092	0.994+-0.120	K	
7 CA *	3.718+-1.222	3.718	3.751+-0.345	1.009+-0.132	CA	
8 TI *	0.607+-0.205	0.607	0.255+-0.022	0.420+-0.040	TI	
9 V	0.049+-0.028	0.049	0.019+-0.004	0.382+-0.090	V	
10 CR	< 0.027	---	0.018+-0.005	0.887+-0.321	CR	
11 MN	0.071+-0.030	0.071	0.116+-0.011	1.631+-0.284	MN	
12 FE *	2.697+-0.804	2.697	3.396+-0.299	1.259+-0.178	FE	
13 HI	< 0.028	---	0.032+-0.006	1.703+-0.642	HI	
14 CU *	1.634+-0.539	1.634	1.653+-0.115	1.012+-0.100	CU	
15 ZN *	3.793+-1.244	3.793	4.065+-0.378	1.072+-0.146	ZN	
16 AS *	0.369+-0.163	0.369	0.437+-0.049	1.185+-0.204	AS	
17 SE	< 0.023	---	0.014+-0.004	1.017+-0.420	SE	
18 BR *	0.134+-0.055	0.134	0.077+-0.008	0.573+-0.071	BR	
19 SR	< 0.044	---	0.028+-0.006	0.799+-0.226	SR	
20 PD	< 0.136	---	0.022+-0.017	0.497+-0.426	PD	
21 AG	< 0.180	---	0.017+-0.026	0.610+-1.091	AG	
22 CD	< 0.296	---	0.280+-0.050	7.246+-9.154	CD	
23 IN	< 0.321	---	0.009+-0.043	0.000+-0.000	IN	
24 SN	< 0.380	---	0.056+-0.049	0.219+-0.194	SN	
25 SB	< 0.677	---	0.044+-0.088	0.000+-0.000	SB	
26 BA	< 1.803	---	0.446+-0.237	0.000+-0.000	BA	
27 HG	0.053+-0.052	0.053	0.026+-0.009	0.498+-0.188	HG	
28 PB *	2.894+-0.957	2.894	3.689+-0.291	1.067+-0.147	PB	

MEAS. AMB. MASS (UG/M3): 100.0

\* - FITTING ELEMENT

Chemical-mass-balance Analyses of Inside  
House Dust -- Fine Fraction from Vacuum  
Cleaner Bag

## CMBDEQ RESULTS FOR CMB # RS411

## COARSE PARTICULATE FRACTION

SAMPLING DATE: 819999 SITE CODE: 09

SAMPLING DURATION: 99 HRS. WITH START HOUR: 99

SITE: House #6

EFFECTIVE VARIANCE FITTING. REDUCED CHI SQUARE: 4.993 D OF F: 9

CODE SOURCE FLG UG/M3 %

1	TRANS.	*	0.099+-	0.052	0.099+-	0.053
12	GEO-I	*	58.839+-	3.792	58.839+-	7.000
64	HDBLD	*	14.149+-	1.252	14.149+-	1.893
74	ZHKLD	*	0.964+-	0.248	0.964+-	0.266
75	CUKST	*	6.094+-	0.844	6.094+-	1.041
<b>TOTAL:</b>			<b>80.145+-</b>	<b>4.091</b>	<b>80.145+-</b>	<b>8.998</b>

SPECIE CODE	COARSE SUSPENDED PARTICULATE				RATIO
	MEAS.	UG/M3	PERCENT	CALC. UG/M3	

1	AL	*	5.438+-	0.544	5.438	5.747+-	0.505	1.057+-0.151	AL
2	SI	*	13.649+-	1.365	13.649	18.255+-	1.797	1.337+-0.220	SI
3	P		0.244+-	0.024	0.244	0.136+-	0.012	0.557+-0.056	P
4	S	*	1.572+-	0.109	1.572	1.012+-	0.145	0.644+-0.110	S
5	CL		0.367+-	0.037	0.367	0.218+-	0.016	0.594+-0.049	CL
6	K	*	1.016+-	0.102	1.016	1.255+-	0.120	1.236+-0.188	K
7	CA	*	2.921+-	0.292	2.921	2.532+-	0.221	0.867+-0.100	CA
8	TI	*	0.541+-	0.054	0.541	0.312+-	0.052	0.577+-0.110	TI
9	V		0.017+-	0.003	0.017	0.023+-	0.002	1.363+-0.236	V
10	CR		0.016+-	0.002	0.016	0.024+-	0.002	1.488+-0.215	CR
11	MN	*	0.083+-	0.008	0.083	0.064+-	0.006	0.773+-0.094	MN
12	FE	*	2.489+-	0.249	2.489	1.993+-	0.145	0.801+-0.074	FE
13	NI		0.029+-	0.003	0.029	0.022+-	0.002	0.769+-0.086	NI
14	CU	*	3.258+-	0.326	3.258	3.537+-	0.331	1.026+-0.150	CU
15	ZH	*	1.173+-	0.117	1.173	1.177+-	0.081	1.004+-0.098	ZH
16	AS	*	0.139+-	0.014	0.139	0.117+-	0.011	0.845+-0.100	AS
17	SE		0.004+-	0.001	0.004	0.008+-	0.001	1.890+-0.439	SE
18	BR	*	0.017+-	0.002	0.017	0.017+-	0.003	0.986+-0.225	BR
19	SR		0.026+-	0.003	0.026	0.034+-	0.002	1.301+-0.149	SR
20	PD		0.007+-	0.005	0.007	0.014+-	0.003	1.974+-1.014	PD
21	AG		0.014+-	0.007	0.014	0.027+-	0.005	1.930+-0.810	AG
22	CD	*	0.057+-	0.013	0.057	0.090+-	0.010	1.572+-0.328	CD
23	IN		<	0.012	---	0.002+-	0.007	0.000+-0.000	IN
24	SH		0.028+-	0.014	0.028	0.027+-	0.009	0.974+-0.430	SH
25	SB		0.040+-	0.027	0.040	0.105+-	0.019	2.635+-1.364	SB
26	BA		<	0.066	---	0.149+-	0.046	0.000+-0.000	BA
27	HG		0.005+-	0.003	0.005	0.006+-	0.001	1.130+-0.445	HG
28	PB	*	1.516+-	0.152	1.516	2.129+-	0.195	1.404+-0.222	PB

AS. AMB. MASS (UG/M3): 100.0

\* - FITTING ELEMENT

Chemical-mass-balance Analyses of Inside House  
Dust-- C Fraction from Vacuum Cleaner Bag

PAGE 0006

## CMBDEQ RESULTS FOR CMB # RL034

## TOTAL PARTICULATE FRACTION

SAMPLING DATE: 819999 SITE CODE: 09

SAMPLING DURATION: 99 HRS. WITH START HOUR: 99

SITE: House #6

EFFECTIVE VARIANCE FITTING. REDUCED CHI SQUARE: 4.053 D OF F: 11  
CODE SOURCE FLG UG/M3 %

14	GEO-K	*	40.794+- 5.292	40.794+- 6.682
15	GEO-L	*	29.797+- 6.148	29.797+- 6.832
78	SECSO	*	2.103+- 0.640	2.103+- 0.674
	TOTAL:		72.694+- 8.137	72.694+-10.911

SPECIE CODE	MEAS.	TOTAL UG/M3	SUSPENDED PARTICULATE PERCENT	CALC. UG/M3	RATIO
1 AL *	5.540+- 0.554	5.540	4.642+- 0.329	0.838+-0.077	AL
2 SI *	13.839+- 1.384	13.839	16.630+- 1.177	1.202+-0.133	SI
3 P	0.207+- 0.021	0.207	0.125+- 0.009	0.606+-0.050	P
4 S *	1.292+- 0.129	1.292	1.292+- 0.021	1.000+-0.089	S
5 CL	0.310+- 0.031	0.310	0.014+- 0.006	0.044+-0.020	CL
6 K *	0.853+- 0.085	0.853	0.968+- 0.068	1.134+-0.121	K
7 CA *	2.885+- 0.288	2.885	2.589+- 0.193	0.898+-0.090	CA
8 TI *	0.534+- 0.053	0.534	0.239+- 0.017	0.448+-0.035	TI
9 V	0.016+- 0.002	0.016	0.016+- 0.001	1.020+-0.103	V
10 CR	0.019+- 0.002	0.019	0.018+- 0.001	0.956+-0.096	CR
11 MN *	0.087+- 0.009	0.087	0.089+- 0.006	1.021+-0.105	MN
12 FE *	2.647+- 0.265	2.647	2.982+- 0.211	1.127+-0.120	FE
13 NI	0.035+- 0.003	0.035	0.026+- 0.002	0.755+-0.074	NI
14 CU *	5.316+- 0.532	5.316	4.186+- 0.346	0.787+-0.083	CU
15 ZN *	1.146+- 0.115	1.146	0.942+- 0.070	0.822+-0.080	ZN
16 AS *	0.136+- 0.014	0.136	0.160+- 0.013	1.179+-0.143	AS
17 SE	0.003+- 0.001	0.003	0.004+- 0.001	1.213+-0.265	SE
18 BR *	0.021+- 0.002	0.021	0.022+- 0.002	1.065+-0.118	BR
19 SR	0.030+- 0.003	0.030	0.028+- 0.002	0.928+-0.090	SR
20 PD	< 0.003	---	0.004+- 0.002	4.047+-7.123	PD
21 AG	0.017+- 0.004	0.017	0.016+- 0.003	0.968+-0.222	AG
22 CD *	0.052+- 0.007	0.052	0.066+- 0.006	1.262+-0.173	CD
23 IN	< 0.005	---	0.002+- 0.004	0.680+-1.499	IN
24 SH	0.034+- 0.007	0.034	0.030+- 0.005	0.884+-0.198	SH
25 SB	0.086+- 0.014	0.086	0.091+- 0.011	1.064+-0.191	SB
26 BA	< 0.031	---	0.056+- 0.021	0.000+-0.000	BA
27 HG	0.006+- 0.002	0.006	0.006+- 0.001	0.941+-0.231	HG
28 PB *	1.645+- 0.164	1.645	1.660+- 0.127	1.009+-0.110	PB

MEAS. AMB. MASS (UG/M3): 100.0

\* - FITTING ELEMENT

Chemical-mass-balance Analyses of Inside  
House Dust-- T Fraction from Vacuum Cleaner

Figure 43

## CMBDEQ RESULTS FOR CMB # GK

TOTAL PARTICULATE FRACTION

SAMPLING DATE: 811001 SITE CODE: 01

SAMPLING DURATION: 24 HRS. WITH START HOUR: 0

SITE: 4-Lane Highway N of CHEMET in East Helena, Mont.

EFFECTIVE VARIANCE FITTING. REDUCED CHI-SQUARE: 1.614 D OF F: 8

CODE SOURCE FLG UG/M3 %

12	GEO-I	*	47.707+- 3.789	47.707+- 4.478
27	LIME	*	4.560+- 1.813	4.560+- 1.828
46	SLAGE	*	15.171+- 1.851	15.171+- 2.000
65	ZNBLD	*	25.002+- 3.589	25.002+- 3.810
68	BLFUP	*	0.458+- 0.153	0.458+- 0.155
75	CUKST	*	14.619+- 1.992	14.619+- 2.028

TOTAL: 107.517+- 6.134 107.517+- 8.157

SPECIE CODE	TOTAL MEAS. UG/M3	SUSPENDED PERCENT	PARTICULATE CALC. UG/M3	RATIO
----------------	----------------------	----------------------	----------------------------	-------

1 AL *	5.452+- 0.545	5.452	5.235+- 0.440	0.960+-0.112	AL
2 SI *	19.627+- 1.963	19.627	17.476+- 1.463	0.890+-0.100	SI
3 P	0.160+- 0.016	0.160	0.150+- 0.008	0.938+-0.072	P
4 S *	1.265+- 0.141	1.265	1.260+- 0.117	0.996+-0.131	S
5 CL	< 0.013	---	0.422+- 0.033	0.000+-0.000	CL
6 K	1.158+- 0.116	1.158	1.539+- 0.103	1.329+-0.156	K
7 CA *	4.255+- 0.425	4.255	4.277+- 0.239	1.005+-0.080	CA
8 TI *	0.299+- 0.030	0.299	0.241+- 0.018	0.805+-0.078	TI
9 V	0.021+- 0.002	0.021	0.014+- 0.003	0.649+-0.167	V
10 CR	0.027+- 0.003	0.027	0.032+- 0.002	1.185+-0.111	CR
11 MN *	0.128+- 0.013	0.128	0.127+- 0.010	0.990+-0.107	MN
12 FE *	3.931+- 0.383	3.931	4.524+- 0.335	1.151+-0.130	FE
13 HI	0.048+- 0.005	0.048	0.051+- 0.003	1.053+-0.100	HI
14 CU *	0.232+- 0.823	0.232	0.288+- 0.792	1.007+-0.137	CU
15 ZN	1.553+- 0.155	1.553	6.158+- 0.482	3.991+-1.276	ZN
16 AS *	0.290+- 0.029	0.290	0.260+- 0.017	0.896+-0.080	AS
17 SE	0.006+- 0.001	0.006	0.008+- 0.001	1.352+-0.216	SE
18 BR *	0.038+- 0.004	0.038	0.033+- 0.002	0.877+-0.077	BR
19 SR	0.039+- 0.004	0.039	0.033+- 0.002	0.848+-0.063	SR
20 PD	0.007+- 0.003	0.007	0.005+- 0.004	4.974+-2.732	PD
21 AG	0.025+- 0.005	0.025	0.021+- 0.003	0.850+-0.147	AG
22 CD *	0.120+- 0.012	0.120	0.121+- 0.008	1.005+-0.089	CD
23 IN	< 0.007	---	0.011+- 0.004	2.108+-1.909	IN
24 SN	0.051+- 0.010	0.051	0.103+- 0.010	2.024+-0.455	SN
25 SB	0.168+- 0.023	0.168	0.078+- 0.010	0.464+-0.066	SB
26 BA	0.101+- 0.041	0.101	0.264+- 0.031	2.617+-0.863	BA
27 HG	0.008+- 0.002	0.008	0.008+- 0.001	1.002+-0.237	HG
28 PB *	2.880+- 0.288	2.880	3.045+- 0.233	1.057+-0.118	PB

DENs. AMBI. MASS (UG/M3): 100.0

\* - FITTING ELEMENT

Chemical-mass-balance Analyses of  
4-Lane Highway in East Helena, Mt.

• Soil Analyses

Roto-tilling, cultivation, irrigation, make-up soils and fertilizers obviously alter garden soil metal concentrations. One would expect mixing of metal concentrations into lower soil regions. At the Hastie garden, x-ray fluorescent analyses by an EPA laboratory in Boston, Massachusetts were performed as follows (the Hastie site is shown in Figure 47):

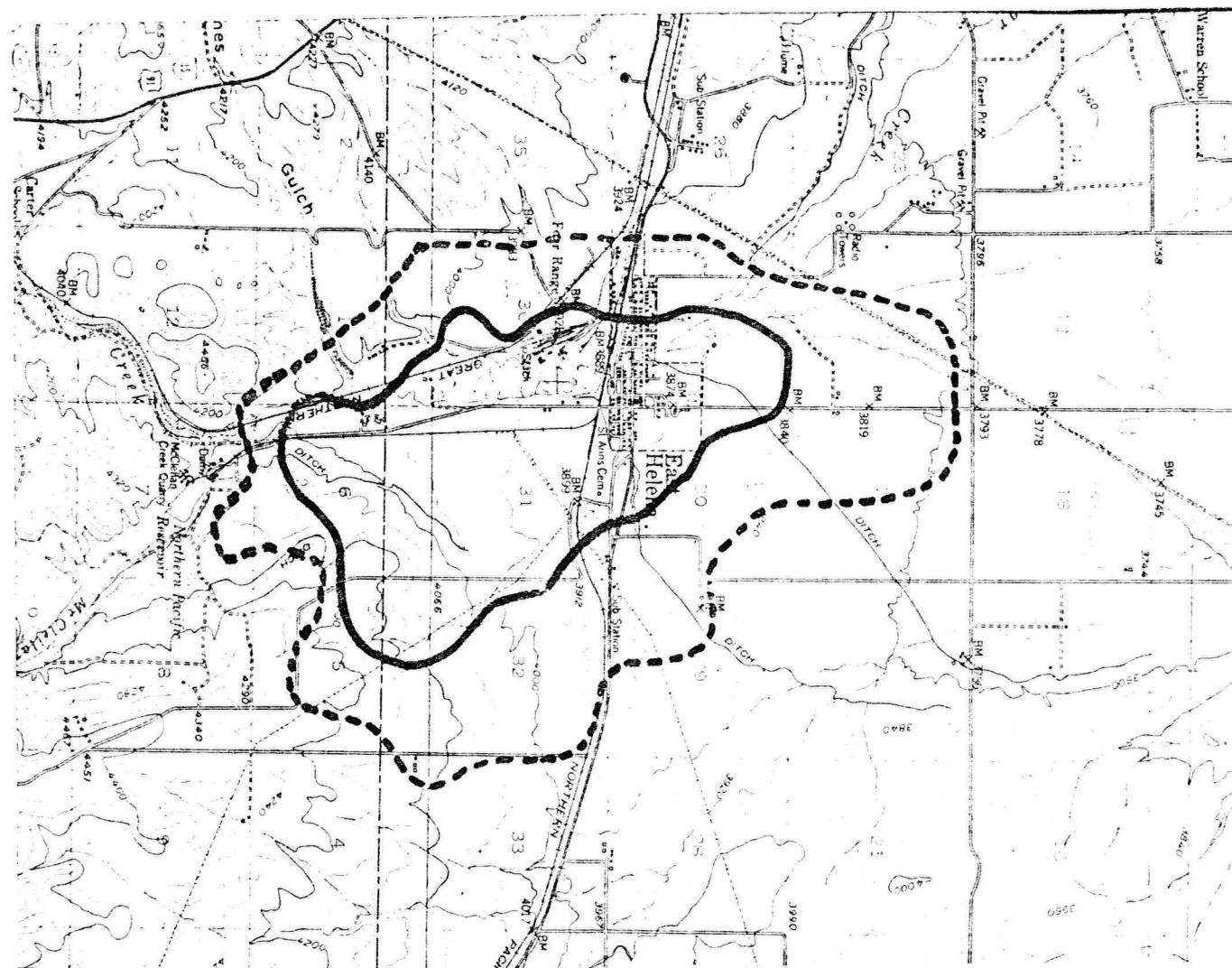
Table 8

Hastie Garden Soil Lead Concentrations

<u>Soil Depth</u>	<u>Lead Conc. (ppm)</u>
0-6"	1284
6-9"	900
9-12"	340
12-15"	340
15-18"	86

Limited correlation of snow-core to soil concentrations for lead indicate that for the East Helena area, approximately 8.4 square miles of land contains at least 1000 ppm lead in the upper one inch of soil. Likewise about 5.5 square miles of land contain 1000 ppm or greater of lead in the upper 0 to 6 inch soil composite. Figure 45 shows the above soil composites. These are large areas and represent tremendous soil lead metal cumulations since 1888, when East Helena smelting began. Based on snow-core data and assuming constant emissions over time, some 6000 tons of lead were deposited within the 5.5 square mile area.

East Helena area road and soil dusts contain high metal concentrations, predominately in small particle sizes. Inhalable (0 to about 15 microns) and respirable (0-2.5 micron) particles, obtained by resuspending soil and roadway



EAST HELENA AREAS WHICH EXCEED 1000 PPM OF LEAD IN THE UPPER 1 INCH OF SOIL, SHOWN AS THE LAND WITHIN THE OUTER DOTTED CONTOUR, AND WHICH EXCEEDS 1000 PPM IN THE UPPER 6 INCHES OF SOIL, SHOWN AS THAT AREA INCLUDED WITHIN THE INNER CONTOUR OR SOLID LINE. THE OUTER AREA INCLUDES SOME 8.4 SQUARE MILES WHILE THE INNER AREA, 5.5 SQUARE MILES.

Figure 45

dusts, are highly enriched in East Helena area dusts. Such fines originated at industrial sources and were transported away from their emission points by air currents. Bulk soils were collected, dried, sieved to less than 38 microns in size, and resuspended into: 0-2.5, 2.5-15, and 0-30 micron size fractions.

Table 9 shows several examples of such size fractionated metal analyses. Chemical analyses were performed by x-ray fluorescent methods. Sample locations are shown in Figure 46; some are composites of similar soils based on bulk chemistry scans. Similar data is available for 33 elements.

Table 9

## Size Fractionated Soil and Roadway Dust with Metal Concentrations in Percentages

Location	Concentration											
	Lead			Cadmium			Arsenic			Copper		
	F	C	T	F	C	T	F	C	T	F	C	T
A Street Locations A	1.996	1.717	1.627	.048	.055	.056	.280	.186	.141	.708	1.625	2.778
B Street Location B	2.142	1.414	1.356	000*	.043	.032	.219	.155	.121	.493	.668	.966
C Four-lane highway C	2.904	2.157	2.178	.059	.061	.078	.390	.229	.209	.643	.868	1.289
D Four-lane Highway D	4.248	3.046	2.880	.416	.146	.120	.602	.320	.290	1.417	3.855	8.232
E Four-lane Highway E	1.298	.796	.869	.049	.038	.021	.161	.079	.076	.229	.240	.282
F Soils Location F	1.110	.879	.798	.039	.026	.003	.091	.084	.063	.119	.152	.217
G Soils Location G	0.954	.787	.898	.045	.029	.047	.115	.063	.066	2.339	2.936	3.643
H Soils Location H	.622	.403	.229	.028	.026	.001	.070	.045	.020	.151	.168	.146
I Cultivated Wheat Field**	.899	.704	--	<.048	<.014	--	.040	.088	--	.048	.035	--

\*Sample very small

\*\*Soil sample 0-6" composite

F = 0-2.5 micron particle size

C = 2.5-15 micron particle size

T = 0-30 micron particle size

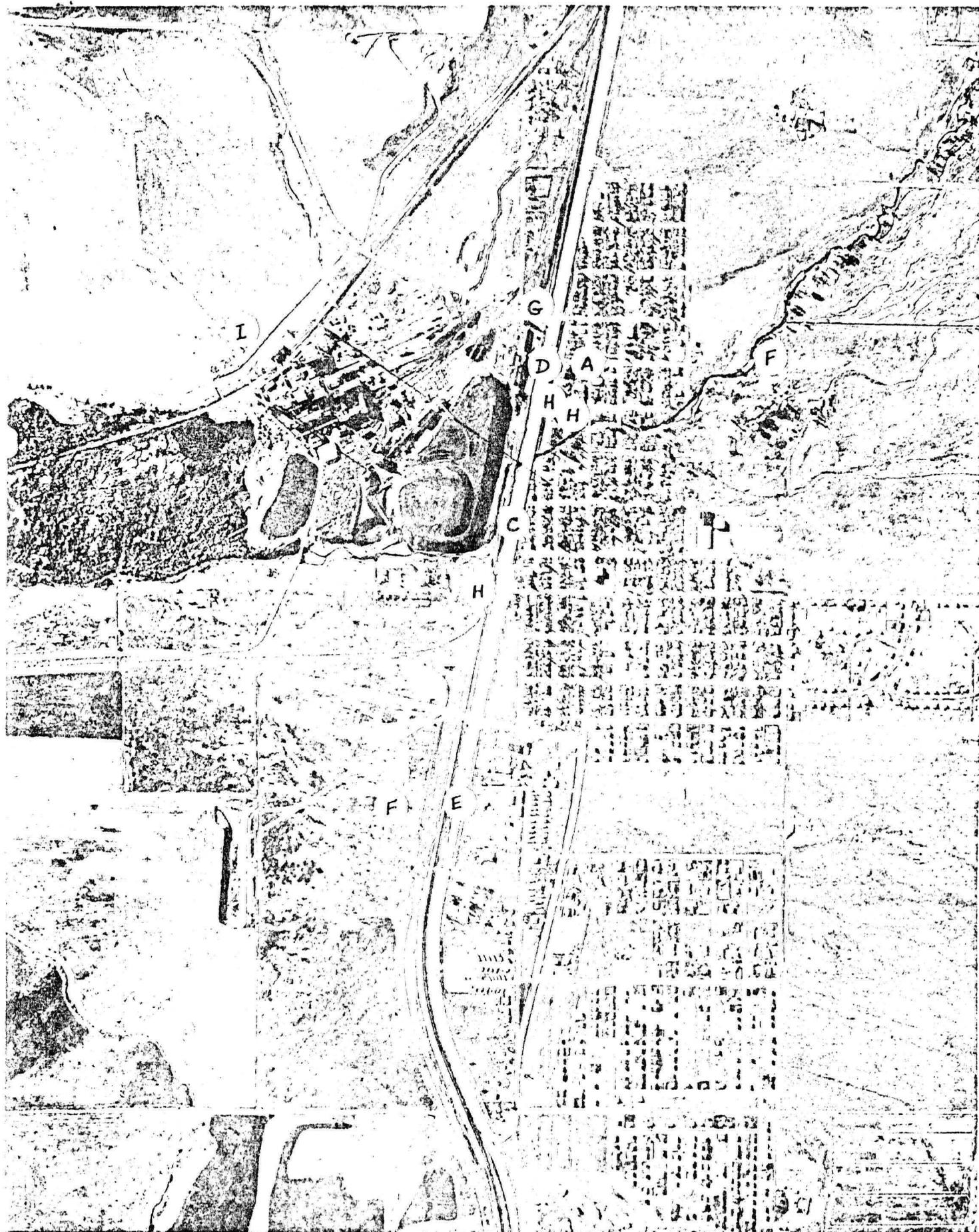
Note: 10,000 ppm = 1%

1,000 ppm = 0.1%

100 ppm = 0.01%

0021603

0021604



EAST HELENA ROAD AND SOIL SAMPLING LOCATIONS-- 1981 Study

Figure 46

65

## Garden Analyses

Figure 46 shows locations of East Helena area gardens sampled.

At the Dartman location, Table 10, total arsenic concentrations were obtained by atomic absorption analyses by University of Montana researchers as follows:

Table 10

Dartman Garden Plants  
(sampled summer 1981)

	<u>Number Samples</u>	<u>Arsenic</u>
Onion Leaves	4	27.44 ppm
Tomatoes	5	1.28
Tomato leaves	5	23.56
Lettuce	5	6.66
Beans	5	24.57
Carrots	5	1.14
Carrot leaves	5	11.05

(samples unwashed)

Table 11

Hastie Garden  
(sampled summer 1979)

	<u>Lead</u>	<u>Cadmium</u>
Lettuce*	360 ppm	70 ppm

\*Washed composite samples

Table 11 shows lettuce concentrations to be high for lead and cadmium in East Helena itself.

From the above, it is clear that additional garden vegetable and fruit sampling should be performed.



EAST HELENA GARDEN SAMPLING LOCATIONS: 1979 and 1981

Figure 47

### Total Suspended Particulates

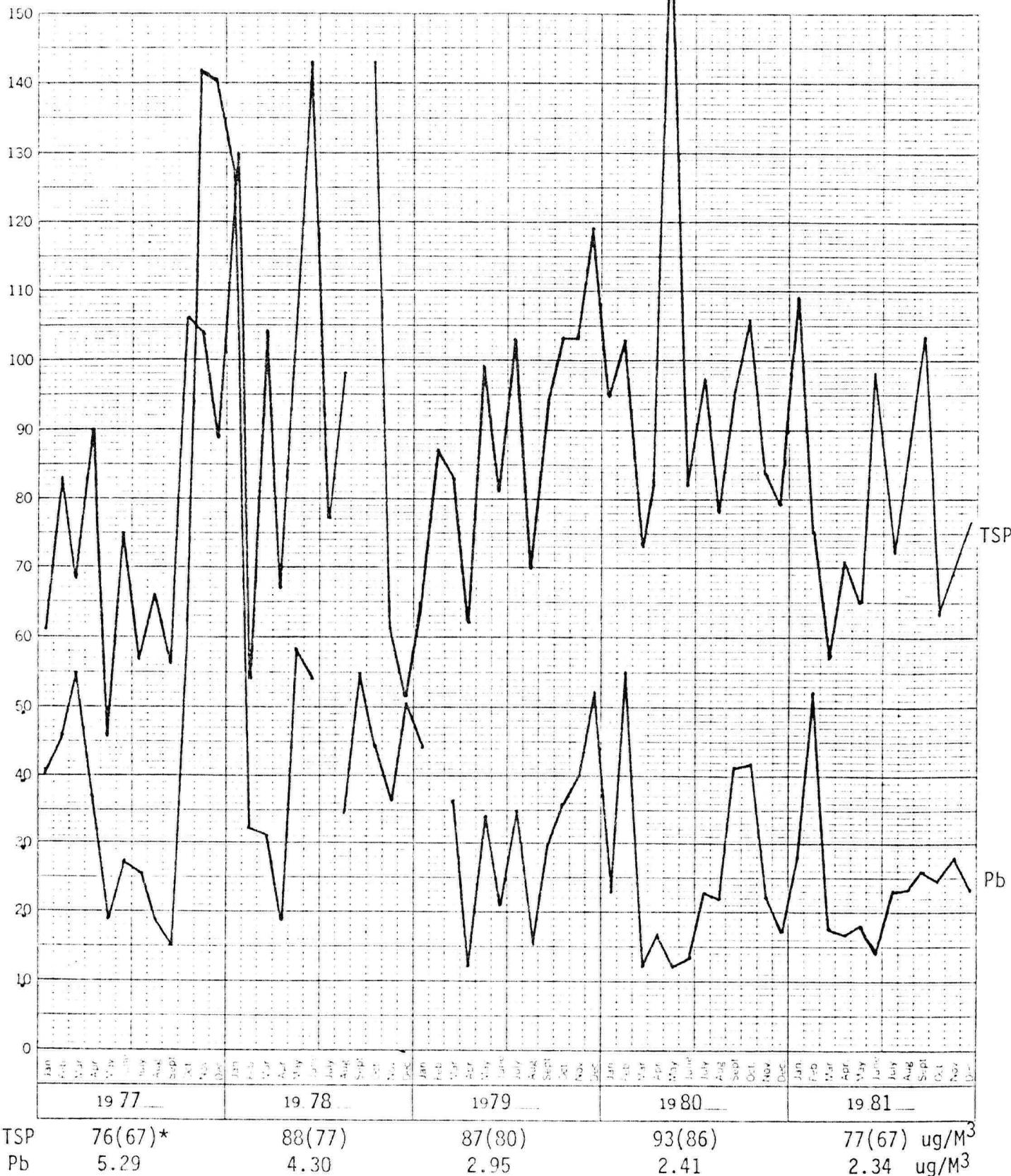
At the Hastie site (see Figures 11 and 12) in East Helena, where hi-vol total suspended particulates (TSP) have been collected since the late 1960's, recent concentrations show violations of Federal and Montana annual standards. Annual geometric mean concentrations should not exceed 75 micrograms of TSP per cubic meter of air sampled. Daily concentrations exceeding the Federal 24-hour violation level of  $260 \text{ ug/m}^3$  are rare, although violations of Montana's 24-hour standard of  $200 \text{ ug/m}^3$  were exceeded three times in 1981 at the Hastie monitoring site.

Figure 48 shows TSP trends for the five years 1977-1981. The upper TSP plot does not show a cyclic trend as is often seen for mountainous inversion prone areas; i.e. particulates are higher in winter periods and lower during warmer periods. Automotive traffic past the site, as can be seen in Figure 30, contributes only one percent as exhaust. Forty-two percent of the dust is labeled as road and soil. The CMB model "fit" the four-lane highway due south of the Hastie site as the contributor of  $19.1 \text{ ug/m}^3$ . However, Figure 44 shows qualitatively that four-lane road dust is composed of about 45 percent "background or pure" roaddust and about 55 percent industrial dusts. This East Helena TSP seems to depend more on industrial emissions, which are rather constant in nature, than on cyclic sources associated with transportation such as winter sanding, spring break-up, etc. Figure 49 shows detailed 1975-1981 TSP data for the Hastie site.

The Hadfield site is found to read TSP values approximately 111 percent of the Hastie values; apparently the Hastie site has not obtained "worst-case" population-oriented data.

## HASTIE SITE

East Helena Total Suspended Particulate (TSP),  
 Lead (Pb) trends 1977 to 1982.

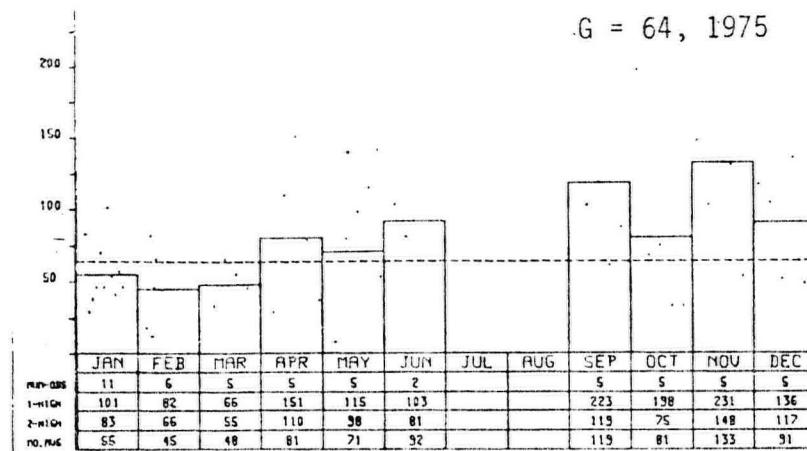


\*Arithmetic (Geometric) means

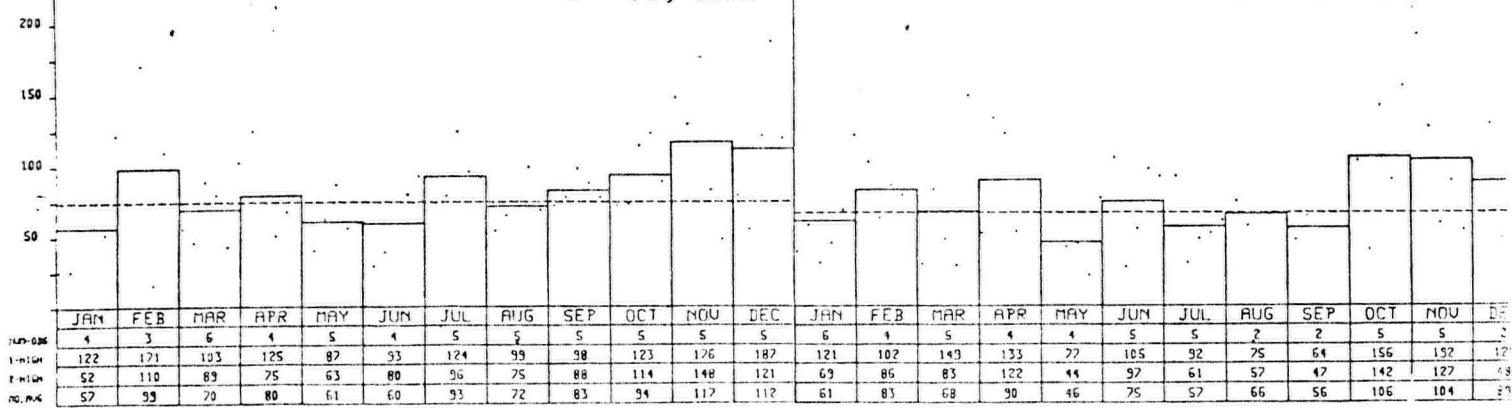
Figure 48

0021609

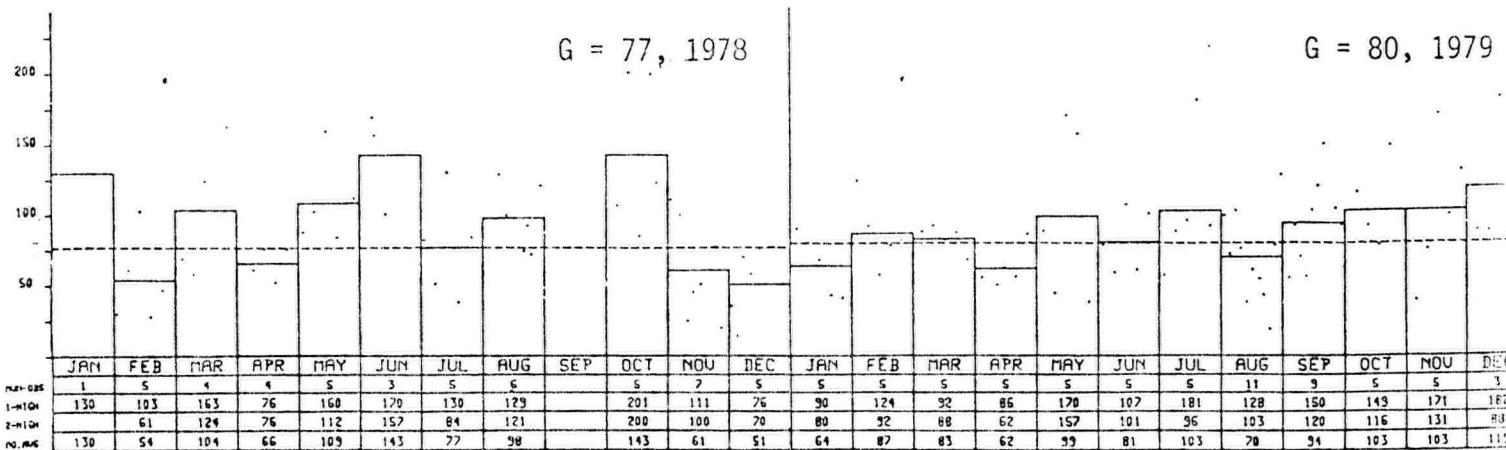
G = 64, 1975



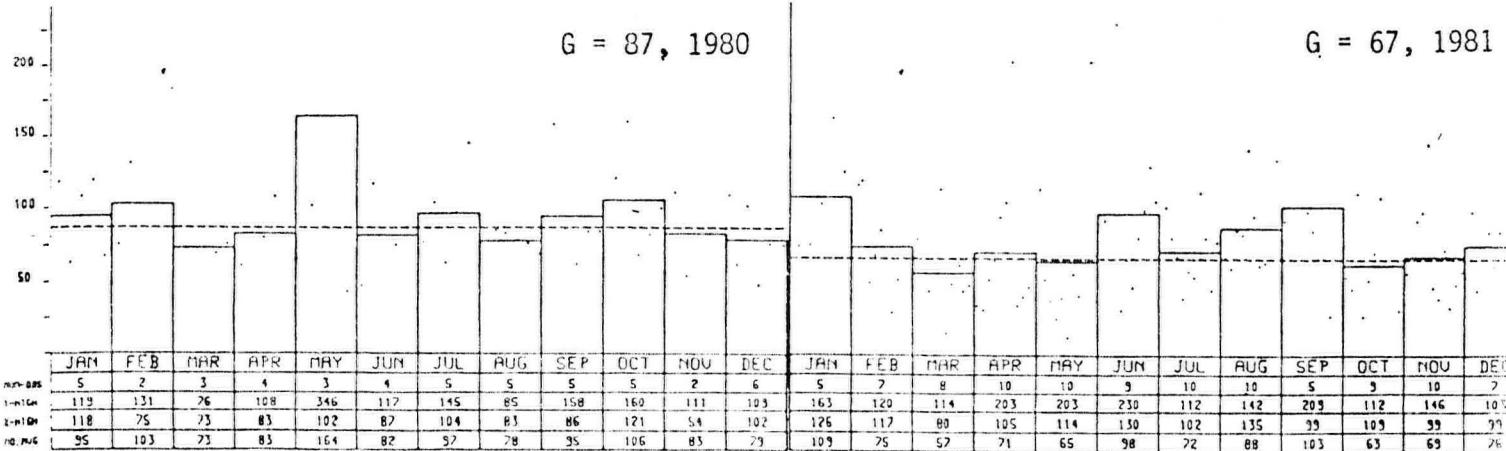
G = 75, 1976



G = 67, 1977



G = 80, 1979



G = 67, 1981

Total Suspended Particulates East Helena HASTIE site.

Again from Figure 48 lead concentrations at the Hastie site have declined since 1978. Lead concentrations exceed federal and Montana ambient standards which are 1.50 ug/m<sup>3</sup> quarterly mean for the federal standard, while Montana utilizes a running three-month average.

ASARCO's lead production is shown in Table 12. These numbers indicate smelter operational levels to some degree. Lead bearing concentrates and ores vary from about 12 to 60 percent (in lead). If low-grade ores and concentrates predominate in any one year, the smelter would handle more of these materials to maintain given production levels. The opposite is also true.

Table 12  
ASARCO Annual Lead Production in Tons

<u>Year</u>	<u>Lead Production</u>
1981	56,746
1980	52,988
1979	59,596
1978	56,463
1977	54,404
1976	64,280
1975	58,558

### Miscellaneous Data

East Helena average daily vehicular traffic (ADV) data are shown in Figure 50.

Usually one drinking water sample per year has been collected by the Montana Water Quality Bureau for metal analysis. These data are shown in Table 13.

Table 13

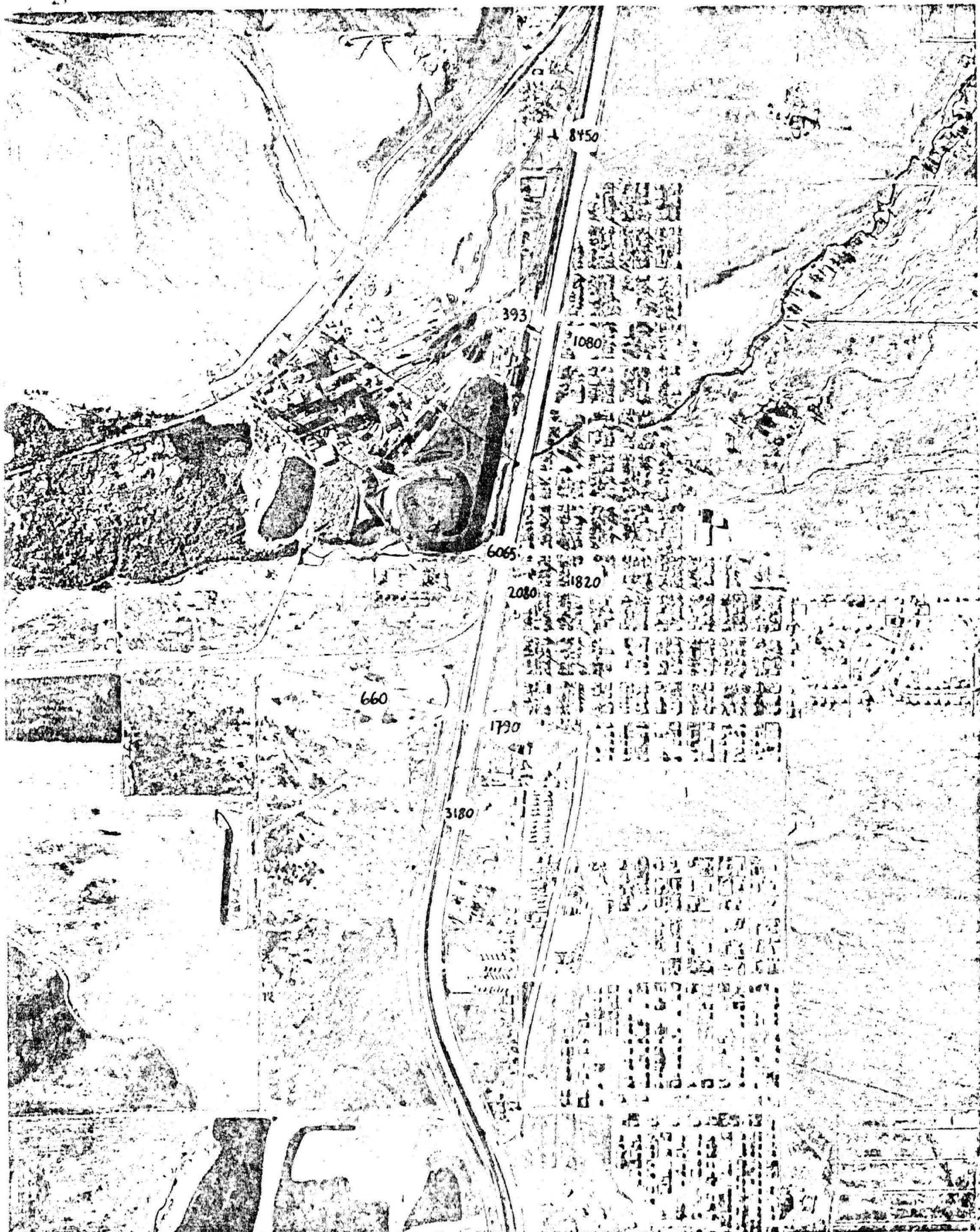
#### East Helena City Water Quality Data (City Hall Samples)

	Pb	Cd	As
May 1978	<.005	<.001	<.001
May 1980	<.005	<.001	<.001
July 1981	<.005		

(concentrations in ppm)

Samples collected only once per year.  
Analyses by atomic absorption spectroscopy.

0021612



EAST HELENA AVERAGE DAILY VEHICULAR TRAFFIC--1979, 1981, 1982 Counts

Figure 50

## 1980 Census Information

Figure 51 shows East Helena City U.S. Census Enumeration boundaries while Table 14 gives general Montana population information and specific population numbers for 0 to 13 year-old East Helena children according to enumeration districts.

Table 14

East Helena Census Data (April 1, 1980)  
(See Attachment 1)

## Population Information

	<u>Total</u>	<u>Median Age</u>
Montana	786,690	29.0
Lewis & Clark County	43,039	28.9
Helena City	23,938	29.5
East Helena City	1,647	31.0
East Helena City	1,651*	

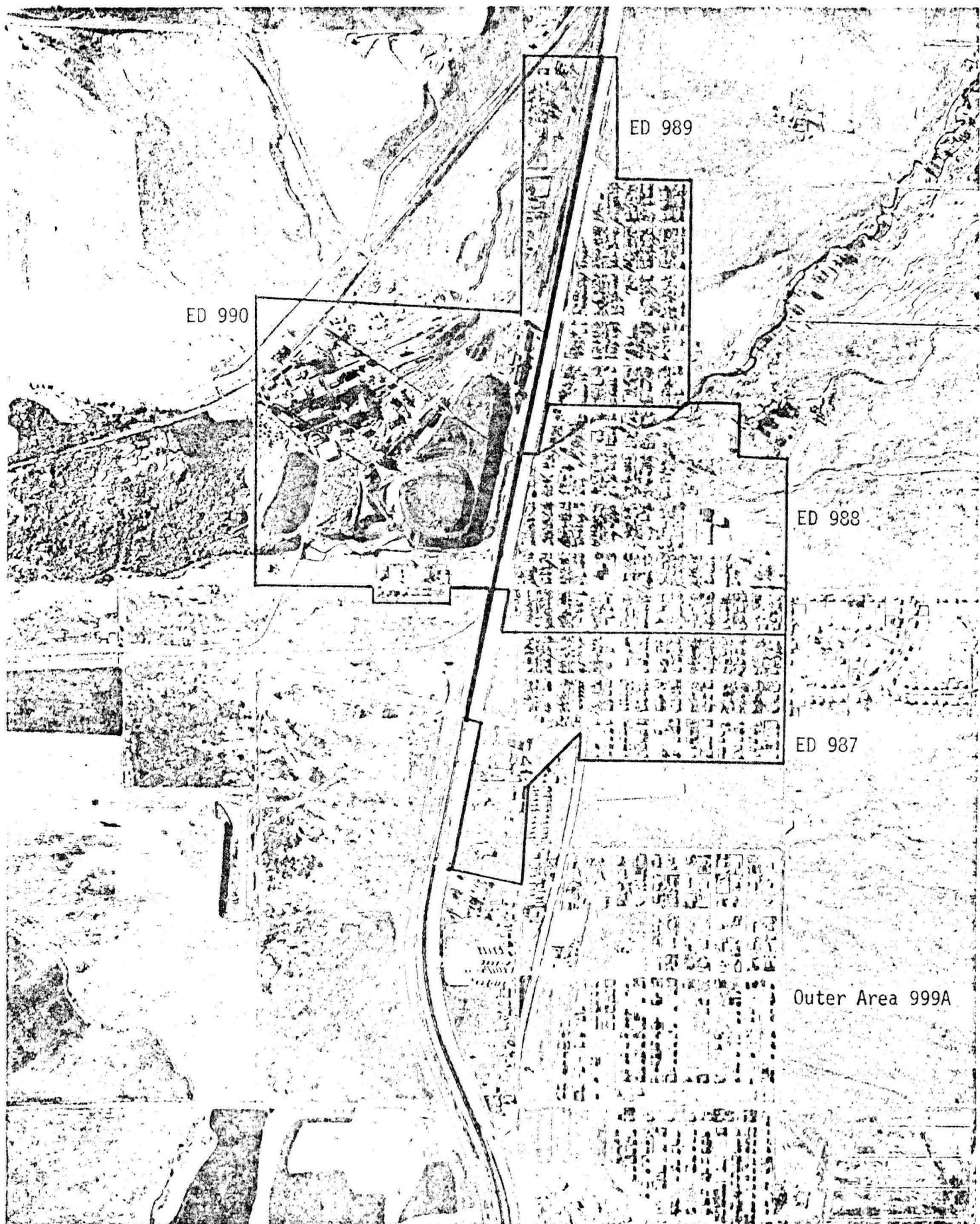
## East Helena and Area Enumeration District Information

	E.D. 987	E.D. 988	E.D. 989	E.D. 990	E.D. 999A
Population	478	693	406	70	2677
Median Age	28.1	31.3	38.6	30	24.8
<1 year	10	13	5	1	80
1-2 years	19	18	9	1	146
3-4 years	15	18	9	2	105
5 years	6	12	3	0	60
6 years	10	16	4	2	60
7-9 years	32	33	20	4	169
10-13 years	27	57	28	6	147

\*1970 Census Data

Median ages for those living near the smelter seem to be definitely above the Montana median age of 29.0 years. This implies that fewer children live close to the smelter, which is fortunate.

Table 15 includes some poverty status information for the City of East Helena.



EAST HELENA U.S. CENSUS ENUMERATION DISTRICTS FOR THE CITY  
City limits are the outer boundaries shown

Table 15

CENSUS OF POPULATION AND HOUSING, 1980--SUMMARY TAPE FILE 3A								PAGE	99
EAST HELENA GEOGRAPHY: STATE: 30 SMSA:	COUNTY:	MCD:	PLACE: 0210	TRACT:	BG:	ED:	UA:	CD:	
59. FAMILIES BY FAMILY TYPE BY POVERTY STATUS IN 1979 BY PRESENCE AND AGE OF RELATED CHILDREN (10)			61. FAMILIES AND NONFAMILY HOUSEHOLDERS BY POVERTY STATUS IN 1979 BY AGE OF HOUSEHOLDER				64. PERSONS FOR WHOM POVERTY STATUS IS DETERMINED BY POVERTY STATUS IN 1979 BY AGE (23)		
TOTAL:									
INCOME ABOVE POVERTY LEVEL:								ABOVE POVERTY LEVEL	BELOW POVERTY LEVEL
WITH RELATED CHILDREN:									
UNDER 6 YEARS AND 6 TO 17	23								
UNDER 6 YEARS ONLY	53		INCOME BELOW POVERTY LEVEL:						
6 TO 17 YEARS ONLY	174		15 TO 64 YEARS	0	13			UNDER 55 YEARS	1274
WITHOUT RELATED CHILDREN	203		65 YEARS AND OVER	0	15			55 TO 59 YEARS	117
INCOME BELOW POVERTY LEVEL:			INCOME BETWEEN 100 AND 124 PERCENT OF POVERTY LEVEL:					60 TO 64 YEARS	45
WITH RELATED CHILDREN:			15 TO 64 YEARS	22	0			65 YEARS AND OVER	212
UNDER 6 YEARS AND 6 TO 17	0		65 YEARS AND OVER	6	42				15
UNDER 6 YEARS ONLY	0		INCOME 125 PERCENT OF POVERTY LEVEL AND ABOVE:				65. PERSONS IN FAMILIES, EXCLUDING HOUSEHOLDERS BY POVERTY STATUS IN 1979 BY HOUSEHOLD RELATIONSHIP AND AGE (10)		
6 TO 17 YEARS ONLY	0		15 TO 64 YEARS	361	50				
WITHOUT RELATED CHILDREN	0		65 YEARS AND OVER	64	39				
FEMALE HOUSEHOLDER, NO HUSBAND PRESENT:								ABOVE POVERTY LEVEL	BELOW POVERTY LEVEL
INCOME ABOVE POVERTY LEVEL:									
WITH RELATED CHILDREN:			62. UNRELATED INDIVIDUALS FOR WHOM POVERTY STATUS IS DETERMINED BY POVERTY STATUS IN 1979 BY AGE (23,24)						
UNDER 6 AND 6 TO 17	0							RELATED CHILD	
UNDER 6 YEARS ONLY	3							UNDER 5 YEARS	85
6 TO 17 YEARS ONLY	14							RELATED CHILD	
WITHOUT RELATED CHILDREN	20							5 YEARS	0
INCOME BELOW POVERTY LEVEL:								RELATED CHILD 6 TO	
UNDER 6 YEARS AND 6 TO 17	0							17 YEARS	413
UNDER 6 YEARS ONLY	0							OTHER FAMILY MEMBER	
6 TO 17 YEARS ONLY	0							566	0
WITHOUT RELATED CHILDREN	0								
60. FAMILIES WITH ONE OR MORE RELATED CHILDREN BY POVERTY STATUS IN 1979 BY PRESENCE AND AGE OF RELATED CHILDREN (10)							66. PERSONS FOR WHOM POVERTY STATUS IS DETERMINED BY POVERTY STATUS IN 1979 (23)		
INCOME ABOVE POVERTY LEVEL:									
WITH RELATED CHILDREN:								INCOME BELOW 75 PERCENT OF POVERTY LEVEL	
UNDER 5 YEARS AND 5 TO 17	23							28	
UNDER 5 YEARS ONLY	53							INCOME BETWEEN 75 AND 125 PERCENT OF POVERTY LEVEL	
5 TO 17 YEARS ONLY	174							121	
INCOME BELOW POVERTY LEVEL:								INCOME BETWEEN 125 AND 149 PERCENT OF POVERTY LEVEL	
WITH RELATED CHILDREN:								115	
UNDER 5 YEARS AND 5 TO 17	0							INCOME BETWEEN 150 AND 199 PERCENT OF POVERTY LEVEL	
UNDER 5 YEARS ONLY	0							160	
5 TO 17 YEARS ONLY	0							INCOME 200 PERCENT OF POVERTY LEVEL AND ABOVE	
								1252	

NOTE: ZERO INDICATES THAT THE NUMBER IS ZERO OR THE DATA IS SUPPRESSED

0021615

### Children Blood lead values

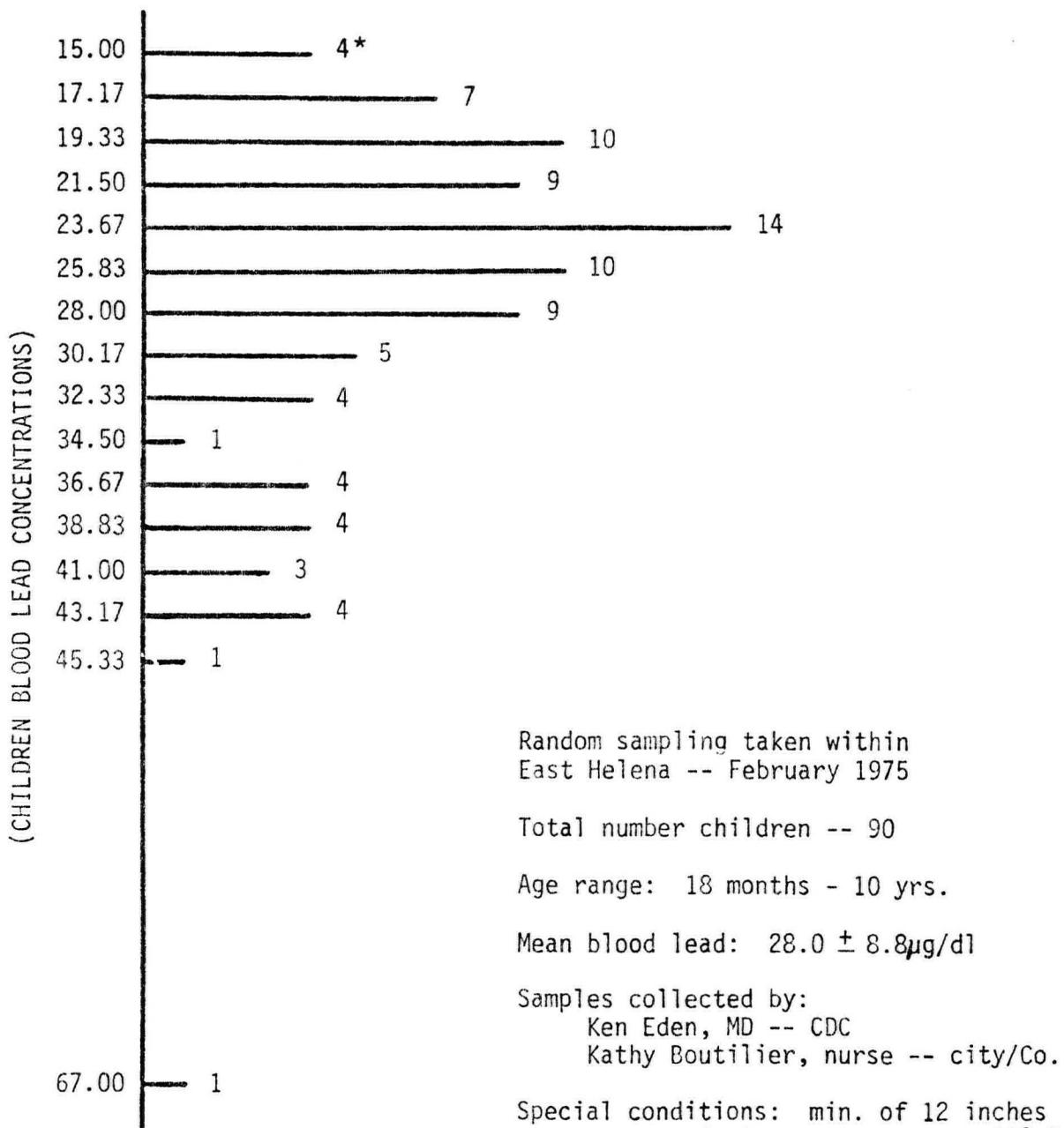
In February of 1975 Dr. Ken Eden, M.D. at that time with CDC but assigned to the Montana State Department of Health, collected blood samples from 90 East Helena children ranging in age from 18 months to 10 years. Table 16 shows details for these blood lead analyses.

CDC lead analyses range from 15 to 67 ug/100 ml with a mean of 28.00 while the Montana State Health Department's laboratory range was 11-56 ug/100 ml of blood lead and mean of 24.87.

At the time of door-to-door sampling in East Helena, snow was about 30 inches deep and temperatures were cold. Consequently, the data should be viewed as "best-case" data. Naturally house dusts would affect the children but outside dust would be suppressed due to cold, frozen streets and snow covered lands.

Montana's chemical analyses were by Delves cup attachment to an atomic absorption device.

## HISTOGRAM: EAST HELENA CHILDREN BLOOD-LEAD VALUES



\* Number of children  
in freq. level

$31 \geq 30$  " or 34.4 % "

$9 \geq 40$  " or 10.0 % "

$1 \geq 50$  " or 1.1 % "

Table 16

0021618

Number	Initials	Age	Sex	Pb(State)	Pb(CDC)
1	J.G.	9 1/2	M	35	37
2	N.G.	8	F	31	33
3	H.G.	6	F	26	29
4	J.G.	4 1/2	M	39	44
5	R.G.	2 1/2	F	28	32
6	A.F.	3	F	21	26
7	T.F.	22 mos.	M	20	22
8	M.S.	3 yrs. 4 mos	F	24	20
9	T.Z.	3 1/2	F	18	21
10	D.Z.	2	M	17	21
11	J.M.	5	M	17	21
12	V.A.	7	F	20	20
13	K.H.	8	F	29	31
14	E.C.	8	F	21	26
15	L.A.	6	F	17	21
16	J.L.	8	M	14	16
17	R.K.	6	M	16	22
18	J.E.	7	M	25	30
19	G.E.	5	M	21	24
20	D.G.	8	F	23	37
21	K.M.	9 11/12		27	16
22	B.M.	8		36	18
23	%M.	7		13	19
24	C.M.	2 1/2		13	15
25	J.H.			25	25
26	K.H.			27	24
27	E.K.	8	M	12	18
28	J.A.	5	M	19	22
29	C.A.	3	F	24	26
30	J.B.	4	M	18	20
31	L.B.	18 mos.	F	26	23
32	T.F.	22 mos.	M	24	23
33	T.S.	3 1/2	M	20	19
34	W.W.	3 1/2	M	22	23
35	B.M.	3	M	40	45
36	A.B.	3	F	21	27
37	T.M.	5	M	29	28
38	C.N.	2	M	31	24
39	M.N.	8	M	32	38
40	L.N.	6	F	35	39
41	C.P.	8	M	35	25
42	M.S.	7	F	30	22
43	D.D.	6	F	22	19
44	A.J.	7	F	31	32
45	A.H.	10	F	22	19
46	G.H.	7	M	27	24
47	K.H.	4	F	29	28
48	S.H.	2	F	26	26
49	M.H.	9	F	28	21
50	K.M.	7	F	19	24

Table 16, continued

51	C.O.	8	F	31	25
52	M.O.	6	F	33	30
53	C.O.	2	F	24	25
54	J.W.	5	M	24	27
55					
56	L.W.	3	F	43	44
57	S.A.	4	M	36	34
58	J.U.	2	F	34	39
59	A.C.	6	F	11	19
60	J.C.	4	M	21	25
61	D.R.	8	M	37	37
62	C.R.	7	M	56	67
63	J.G.	9	M	35	47
64	J.H.	6	M	24	24
65	D.H.	4	M	16	24
66	D.G.	6	M	36	43
67	J.G.	4	M	21	41
68	D.S.	7	M	13	27
69	J.R.	3 1/2	F	17	24
70	K.R.	4 1/2	F	11	23
71	P.R.	7	M	12	25
72	M.R.	9	F	16	15
73					
74					
75	S.N.	3	F	29	28
76	A.N.	4	M	31	39
77	B.N.	2 1/2	F	31	40
78	D.P.	5	M	23	26
79	S.P.	4	M	31	30
80	D.H.	2 1/2	F	19	36
81	M.D.	6	M	28	34
82	S.D.	4	F	31	41
83	B.S.	5	M	16	23
84	C.A.	6	M	15	20
85	J.A.	22 mos.	M	11	20
86	D.M.	5	F	19	28
87	H.M.	22 mos.	F	24	31
88	S.H.	5	M	18	27
89	P.L.	7	M	26	30
90	T.T.	9 11/12	F	19	27
91	J.T.	8	M	27	32
92	J.T.	5	M	38	44
93	T.J.	7	F	26	34
94					
95					
96					